TECHNOLOGY DEPARTMENT

Power Generation

and POWER PLANT ENGINEERING

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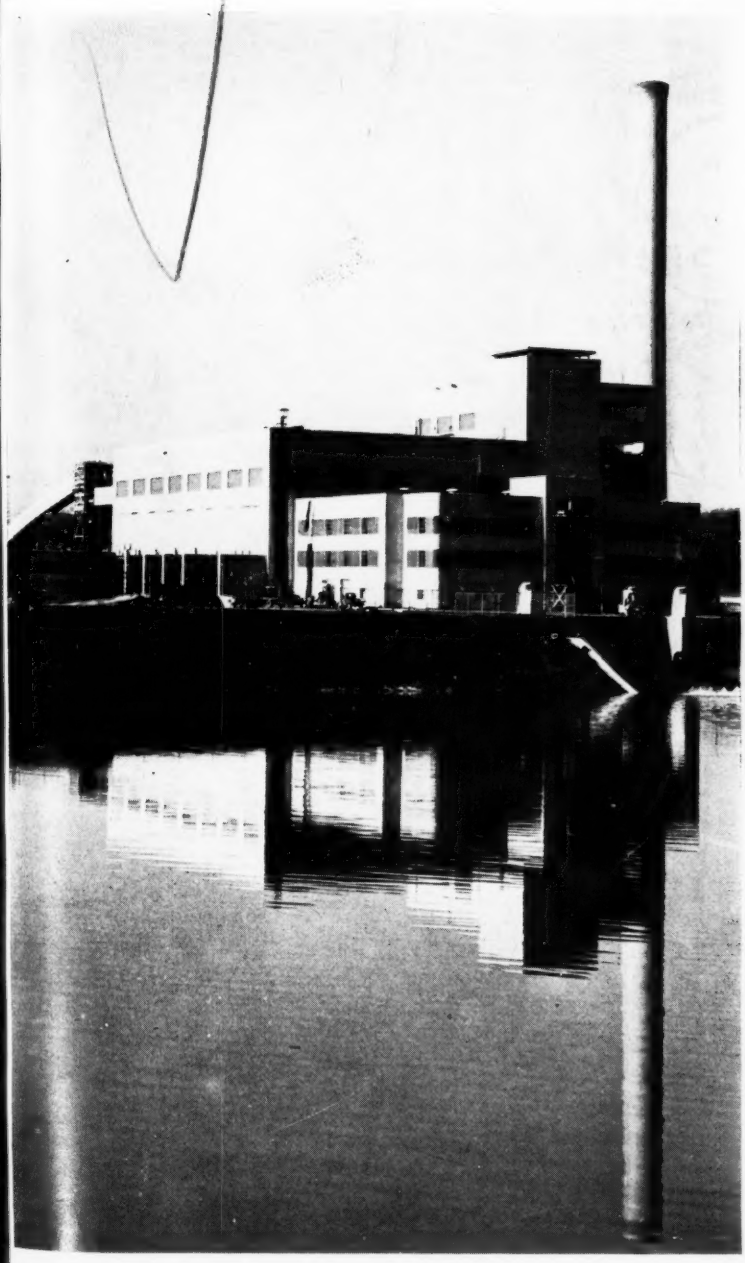

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COVER: View across Great Miami River showing new O. H. Hutchings Station of The Dayton, Power and Light Company, Initial 60,000-kw unit, with semi-outdoor boiler, placed in service in July, 1948. Designed for ultimate expansion to 360,000 kw

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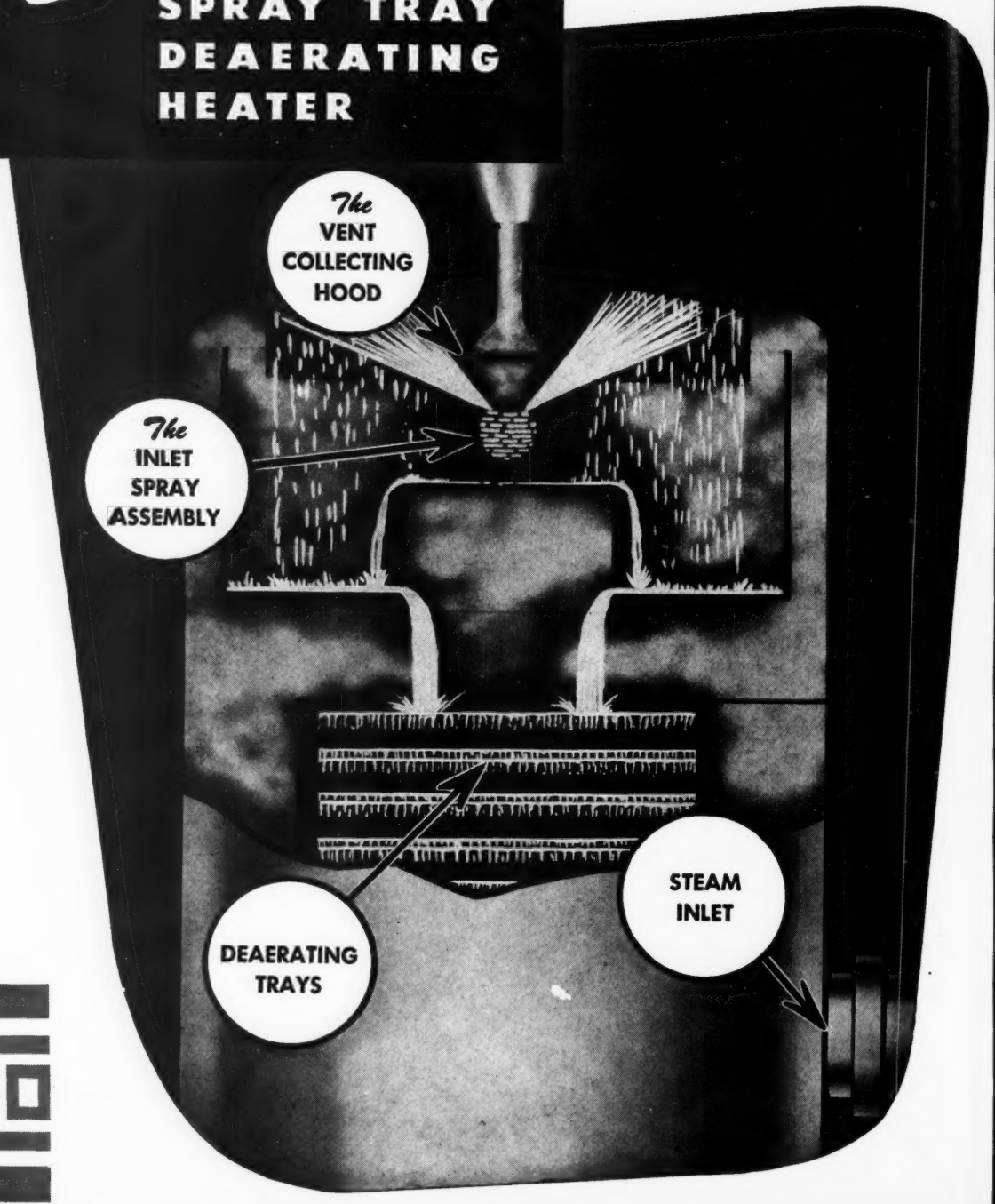

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play in deaeration!

OUT -with corrosive gases -with maintenance costs

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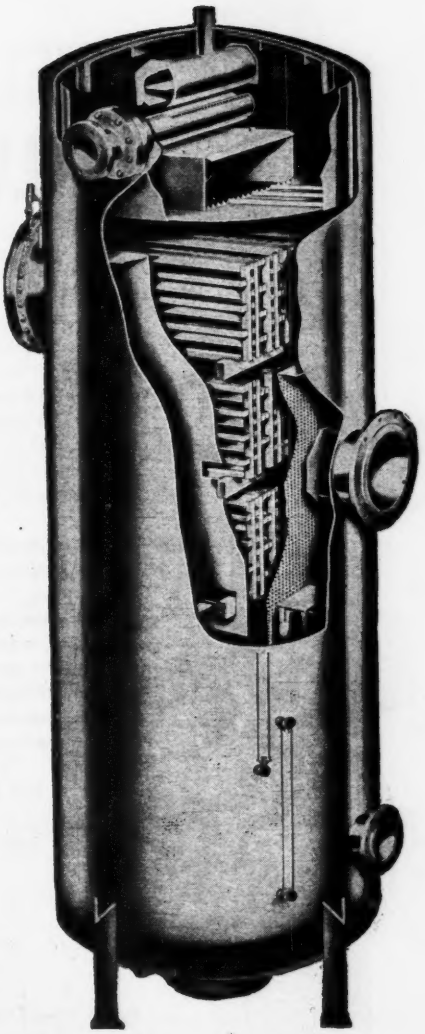
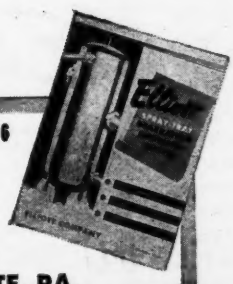
And, of course, you get feedwater heated to the saturated temperature of the steam supplied to the heater.

All in all, another step ahead in power progress, by an organization which pioneered deaeration some years ago, and is still breaking trail.





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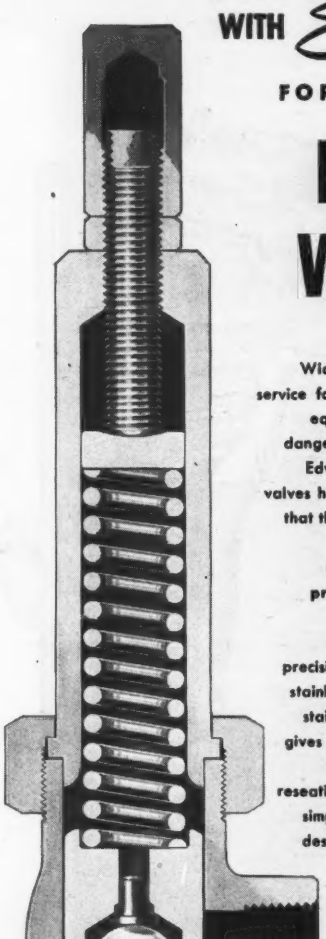

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Power Generation

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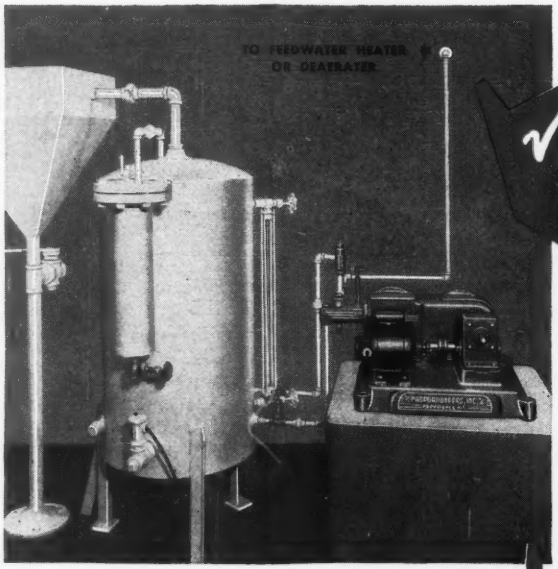

√Checks oxygen in feedwater
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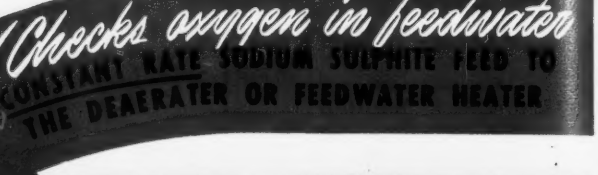

√Checks corrosion and scale
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ENGINEERS' PREVIEW

ALL ENGINEERS need to keep on tap a certain amount of technical data without having to run to the handbooks every time they need it or without having to re-calculate it each time a question comes up. A good illustration of this was given the other day when we were having lunch with Harry W. Smith, Jr. and several members of his staff. In the course of a rather technical discussion, it became necessary to remember the value of π to seven or eight places of decimals. Mr. Smith, it turned out, was a former professor of mathematics and explained that mathematicians have a number of ways of remembering things like that, sometimes by means of jingles and rhymes or sometimes by relations with other factors. In the case of π, he said, here are a couple of ways in which he was taught to remember it and has taught many students to do so. In this rhyme, just put down under each word the number of letters in the word and you have π to 13 decimal places:

How I wish I could recollect of circle round
3. 1 4 1 5 9 2 6 5
The exact relation Arkimedes found
3 5 8 9 5

Of course, he pointed out, you have to change the spelling of Arkimedes from that commonly used in English, to make it fit properly.

Another trick for remembering π, which you can use when you want to show off your French, said Mr. Smith, is as follows:

Oui j'aime a faire apprendre
3. 1 4 1 5 9
Un nombre utile aux sages
2 6 5 3 5

Ordinarily, the value 3.1416 or, at the most, 3.14159, as used in practically all ordinary engineering calculations, will be sufficient for everything you have to do and you may not need the value of π to 10 decimal places more than once or twice in your life. But if you can remember one of the above just at the right time, it may come in very handy.

★ ★ ★

SMALL-SCALE manufacture of titanium metal, a new basic raw material for industrial development, has been begun by the DuPont Company. A pilot unit of 100 lb daily capacity has been successfully placed in operation at the Newport, Delaware, plant of the Pigments Department. This, so far as the company knows, is the first time ductile titanium metal has been produced for commercial exploration. The U. S. Bureau of Mines has been producing the metal for research purposes. The silver-white metal is light and strong. It is highly resistant to corrosion and has a higher melting point than the commonly used metals. It is comparable to stainless steel in strength and corrosion resistance, but weighs only a little more than half as much per unit of volume. It is less than twice as heavy as aluminum, but several times as strong, in bars of comparable dimensions. DuPont is producing and offering it for exploration as a basic raw material for industry and engineering. It has many interesting properties, but exhaustive research will be needed to develop the full possibilities of titanium metal. When this work is done and if titanium alloys work out as expected, scientists believe they may have a new family of structural materials far superior in many ways to any metals or alloys now known.

GLENZIP, if it works out as designed, promises to be one of the greatest boons to humanity devised in our time. It is the first zipper repair tool and is expected to be the most useful device since the invention of the zipper itself. It is a set of three tools, no bigger than a dentist's extraction equipment, designed to repair any size zipper on the market in a fraction of a minute, and to be adjustable to all zipper problems. The tools are designed and equipped to: remove damaged or jammed zipper slides without removing the zipper or parts; open the slide if the fabric is caught, without damage to the fabric; open new slides to replace damaged slides; install top and bottom stops in a fraction of a moment; replace broken teeth; remesh any size zipper; tighten loose teeth; and replace the slide perfectly for smooth zipping. The equipment is now being manufactured and can be made available to any user, seller or manufacturer of any product containing zippers.

★ ★ ★

TINY highly-sensitive electrical resistance elements may now be bonded to cantilever beams to detect and measure changes of stress or load, and minute deflections. For example, automatic control of Bird Machine Co.'s centrifugal filters for dewatering fine coal is accomplished by means of one of these load-sensitive, resistance wire strain gage devices. The complete load-sensitive unit is a sturdy Load-Beam on both sides of which special Baldwin SR-4 gages are bonded. These small, highly sensitive gages, consisting of fine wire grids, are baked on a cantilever Load-Beam, in this instance a 4 by 1 in. steel beam approximately 15 in. long, and covered with a protective Neoprene coating and sturdy metal sheath. Torque required to convey coal through the filter is transmitted to the Load-Beam by means of a vertical arm, which pulls on the beam through a flexible link and strains the outer fibers to which the SR-4 gages are bonded, thus changing their electrical resistance. This change of resistance affects an electronic controller circuit, is translated into pounds of load on the recorder chart. If the filter load exceeds a set value, the feed is cut off automatically until the machine has cleared itself. If the load continues to increase, however, beyond a maximum safe value, not only is the feed cut off but the machine is stopped. The same occurs if the torque load becomes zero, as when a shear pin breaks in the drive.

★ ★ ★

STUDENTS of the gas turbine — and who isn't, these days? — will find that a recent listing of basic information sources on gas turbines and turbosuperchargers issued by the U. S. Department of Commerce, is one of the most valuable publications through which they can keep track of the work done in this field up to date. The publication is entitled, Gas Turbine and Turbosuperchargers (Basic Information Sources) and is prepared by the Inquiry Reference Service of the U. S. Department of Commerce. It contains lists of publications by the government departments, such as the Bureau of Standards, Office of Technical Services, Bureau of Mines, Bureau of Ships and others, on all phases of gas turbine work; then gives a list of nongovernment publications, such as recent books; lists directories in which equipment can be found; and concludes with a comprehensive tabulation of articles in the trade and technical magazines.

BRAIN TEASER—As a little digression from the rigors of generating steam and power, we published a brief item about an inverted check in the October 1948 issue of *Engineers' Preview*. It went like this: A man went into a bank recently to cash a check made out for X dollars and Y cents and the paying teller handed him Y dollars and X cents. After managing to get out of the bank with his ill-gotten gains, the man spent $3.50 of the amount given him by the teller and then found he still had twice as much money as the check originally called for. What were the values of X and Y?

This brain teaser originally appeared in Sparling *Metrograms*. We received considerable comment on it and many readers told us that the answer was: The check was originally written for $14.32. But few of them gave the method by which they obtained this answer. We fooled around with the problem ourselves by various cut and try methods, and finally checked it. But one reader, Dr. Arthur Bessey Smith, vice president, Automatic Electric Laboratories, Inc., sent us the method by which he solved the problem and here it is.

SOLUTION:—

a. X and Y must be integers, not fractions
b. Y cannot exceed 99
c. Y must be greater than X
d. The solution can be obtained only by successive calculations, taking the first integer obtained.
e. We must use only cents, not dollars.

Now if we let C represent the amount of the original check, and D represent the amount of money delivered in payment, and remember we must use only cents, then we can write the following equations:

Original check — $C = 100\,X + Y$ (1)

Delivered amount — $D = 100\,Y + X$ (2)

Now we know from the original problem that:

$$D = 2\,C + 350 \quad (3)$$

Therefore, substituting equations (1) and (2) into (3) we get:

$$100\,Y + X = 2\,(100\,X + Y) + 350 \quad (4)$$

Now if we solve (4) for Y and insert successive integers for X, we can get the answer. Solving (4) for Y we get:

$$Y = \frac{199\,X + 350}{98}$$

Finally, put integral values of X, beginning at 0, into this equation, solve for Y and tabulate the results thus:

X	Y		X	Y	
0	3.57143		8	19.816	
1	5.602		9	21.847	
2	7.63		10	23.8	
3	9.66		11	25.908	
4	11.69		12	27.939	
5	13.72		13	29.96	
6	15.755	→	14	32.000	←
7	17.781		15	34.13	

Since the first integral value of Y comes out 32 for X=14
ANSWER: X=14, Y=32. Original check was for $14.32.

"It seems to me that my method is logical even if it does involve successive calculations," comments Dr. Smith. "There are four unknown numbers yet only three equations, hence there is no explicit solution."

"Though not affecting the cost of generating power, your check problem was a good exercise and diversion."

Another reader, G. Symonds, one of the engineers in a large central station way down yonder below the Mason and Dixon Line, made us the following sporting proposition: "Saw your brain teaser in the October issue of *Power Generation*. Just before pay day we anticipate a nice steak dinner. But when we get our net pay check we settle for fish and grits—if we are lucky enough to catch the fish! However, if you will send us the address of the paying teller in the problem, in return for values of X=14 and Y=32, we will sure eat steak next pay day."

A PLAN to recognize, through Public Interest Awards, exceptional service to the promotion of safety, performed by press, radio, magazines, motion pictures, advertising and advertising organizations, has been announced by National Safety Council. The awards will be non-competitive and are made as a means of recognizing the fine job that so many organs of public opinion and information are doing in promoting safety in their various fields. Nominations for eligibility for these awards are to be made by procedures outlined by the council and the closing date for 1948 entries in all fields is March 15, 1949. Entries should be addressed to Paul Jones, Director of Public Information, National Safety Council, 20 N. Wacker Drive, Chicago, Ill., who will supply all details of the plan.

★ ★ ★

NUMBER of small businesses in the country today, per thousand of population, is as large as at any time in our history and numerically there is no downward trend in sight, according to A. D. H. Kaplan, economist, whose report, "Small Business: Its Place and Problems," has been issued by the Research and Policy Committee of the Committee for Economic Development. This does not rule out the probability that the next few years will see a weeding out among the small businesses that mushroomed in the wartime and postwar sellers' market.

While small business has maintained its strength in numbers, it has lost some ground in the proportion it does of the nation's business. Three main factors will affect its future vitality, according to Kaplan: first and foremost, improved management; also greater availability of equity capital and an improved long range program of federal taxation.

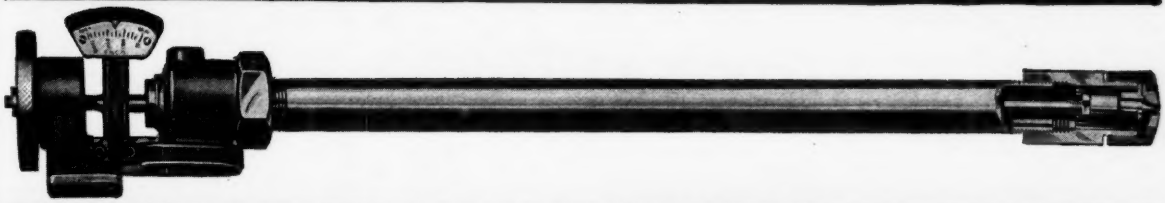
In reviewing the present state of small business, Kaplan points to its importance for a healthy free enterprise economy and for our democratic society. In 1939, small business represented the source of 11 million jobs. If it is to contribute its future share to high productivity and employment, we should look to small business for 14 million jobs.

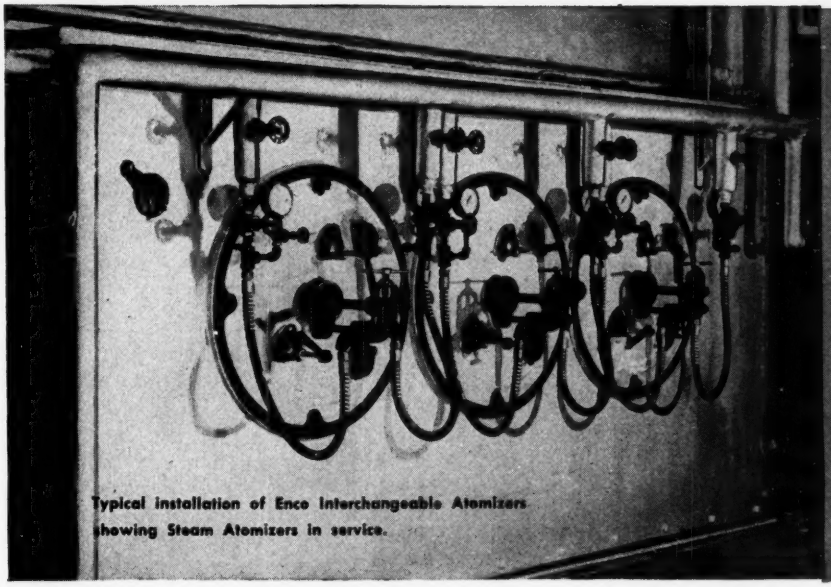
With production and marketing demanding increasing skills, Kaplan cites improvement of small business management as the most necessary step toward strengthening it. Business itself—both big and small—has responsibilities in this regard, he points out, and there are steps to be taken by the community and by business organizations.

★ ★ ★

TO MAKE INDIA self-sufficient in production of newsprint and ultimately in other forms of paper, National Newsprint and Paper Mills, Ltd., Bombay, will construct the country's first newsprint mill, according to its manager, Pran Nath Nair. Ebasco Services, Inc. will design the mill and a power plant to service it, for erection at a cost of about $8,000,000, at Chandni in Central India. The mill, expected to be in operation by the end of 1949, will have a capacity of about 100 tons a day. An interesting feature is that the new mill will use wood from the native bamboo and salai trees for making newsprint. Both trees are fast growing—four years for bamboo and six to ten years for salai. Available supplies are large, and research for the process was done at the Pulp and Paper Institute of Canada. Experiments have also been made on use of the paper mulberry tree.

ENCO WIDE RANGE Mechanical Atomizer





Typical installation of Enco Interchangeable Atomizers showing Steam Atomizers in service.

A complete line of gas and liquid fuel burners are designed and built by ENCO to meet the wide range of capacity requirements of steam plants, refineries, kilns and industrial process furnaces. Two of these are:

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Designed to minimize operating troubles in either full load or ignition service, the Enco wide range mechanical atomizer will handle a capacity of 10 to 1 . . . without changing burner tips when using 300 psi oil pressure. This equals the performance of *five* ordinary atomizers.

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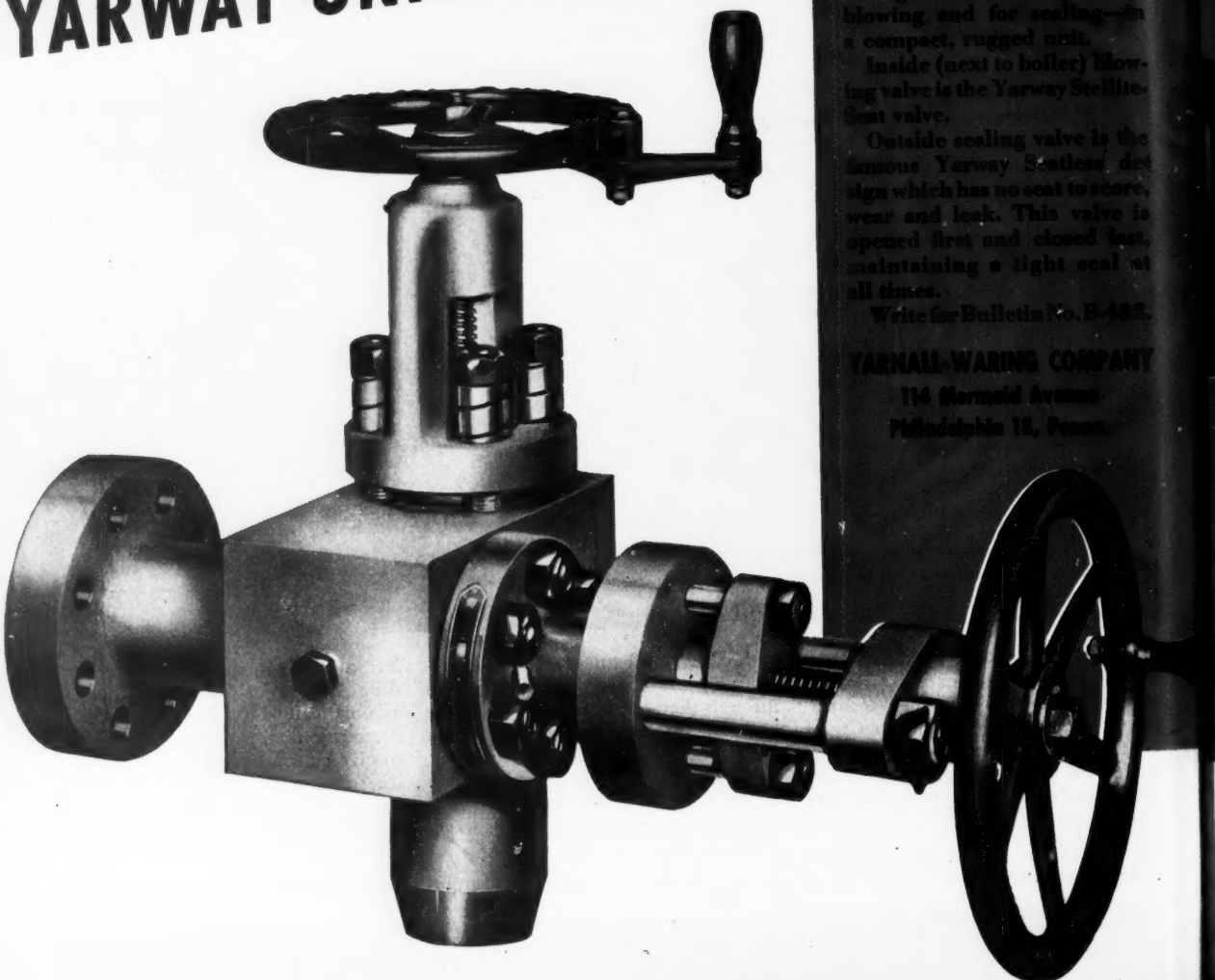

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Yarway Unit Tandems are built for pressures up to 2560 psi. Combining a Stellite-Seat and a Seatless valve in a single one-piece forged steel body, this tandem provides the advantages of both designs—for blowing and for sealing—in a compact, rugged unit.

Inside (next to boiler) blowing valve is the Yarway Stellite-Seat valve.

Outside sealing valve is the famous Yarway Seatless design which has no seat to score, wear and leak. This valve is opened first and closed last, maintaining a tight seal at all times.

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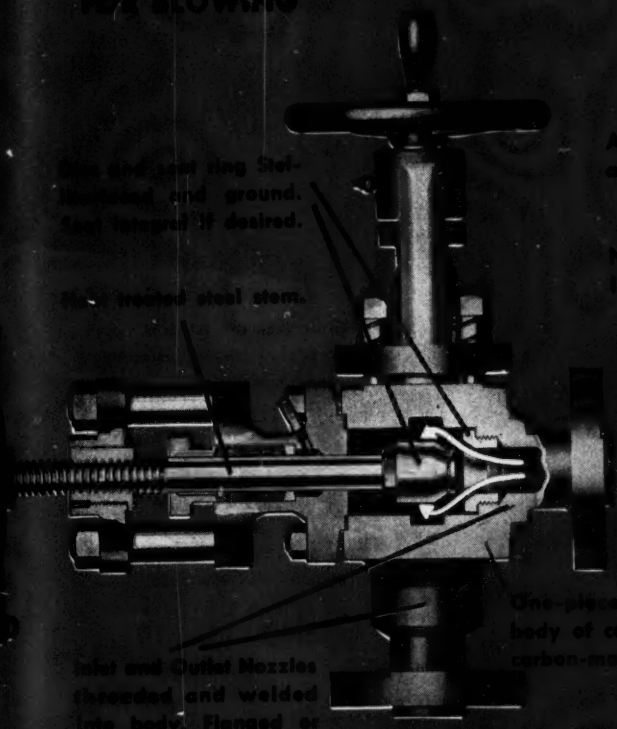
YARWAY

PRESSURES



STELLITE-SEAT VALVE FOR BLOWING

Stellite seat ring Stellited and ground. Seat integral if desired.

Stainless steel stem.

Inlet and Outlet Nozzles threaded and welded into body. Flanged or welded ends provided.

SEATLESS VALVE FOR SEALING

Alemite lubrication of plunger and ball thrust bearing in yoke.

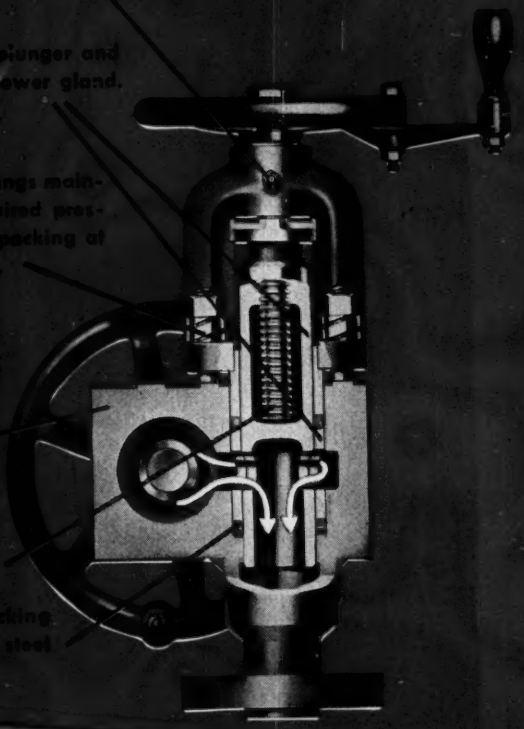
Nitralloy plunger and lower follower gland.

Yoke springs maintain required pressure on packing at all times.

One-piece forged body of carbon or carbon-moly steel.

Stainless steel stem.

Laminated lower packing ring with stainless steel reinforcing inserts.



A FEW REPRESENTATIVE USERS OF HIGH PRESSURE YARWAY BLOW-OFF VALVES

• UTILITIES •

Philadelphia Electric Co.
Boston Edison Co.
Pacific Gas & Electric Co.
Pennsylvania Power & Light Co
Georgia Power Co.
Cleveland Elec. Illuminating Co.
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R. J. Reynolds Tobacco Co.
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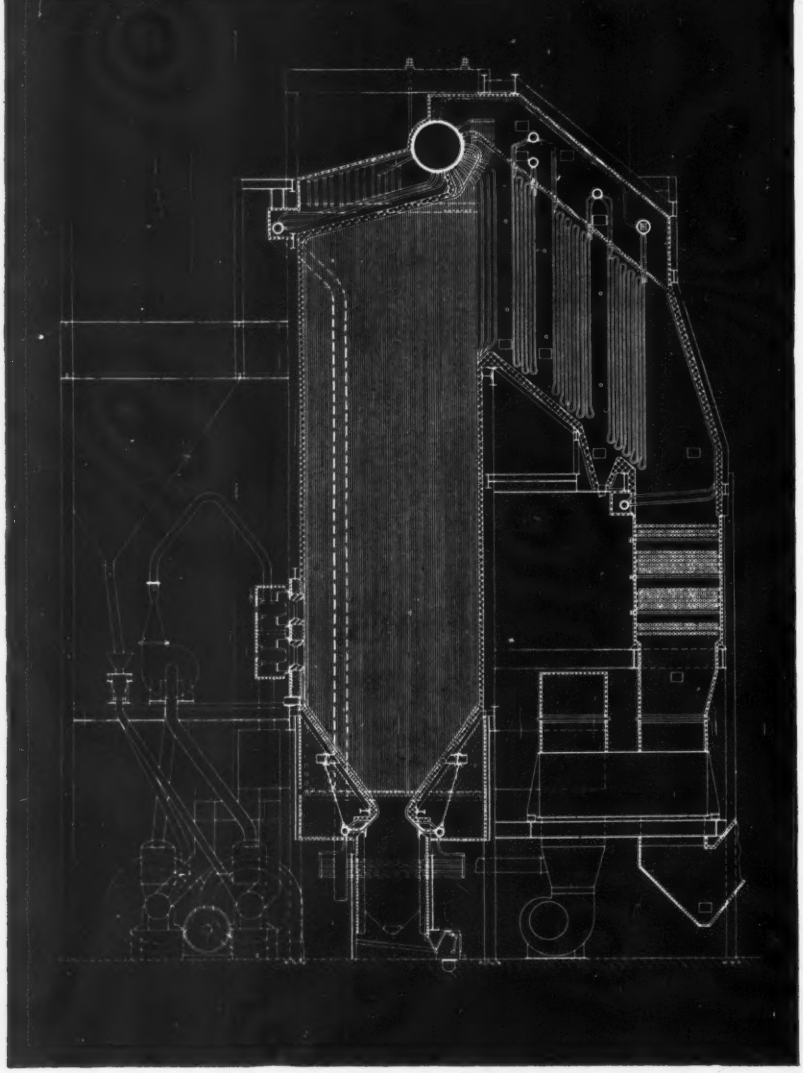
American Viscose Co.
Lever Bros. Co.
Armstrong Cork Co.
Bethlehem Steel Co.

Y BLOW-OFF VALVES



E. M. POSTON STATION
COLUMBUS AND SOUTHERN OHIO ELECTRIC COMPANY

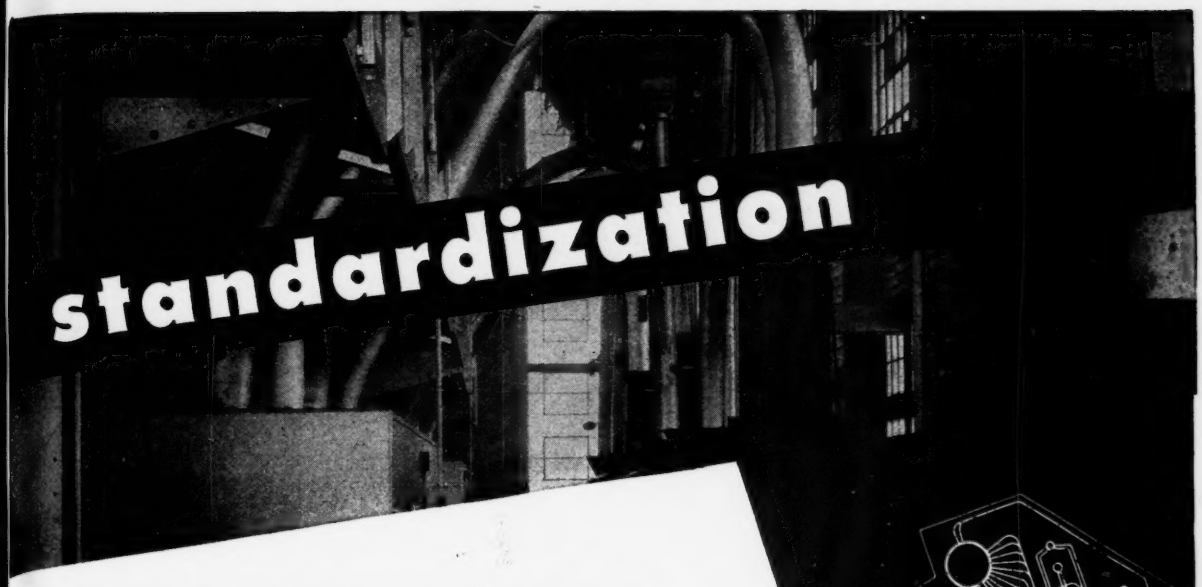
Steam Capacity
425,000 lb per hr

Superheat control range
300,000 to 425,000 lb per hr

Pressure superheater outlet
1354 psi

Final steam temperature
955 F

Bituminous Coal Pulverized
in FW Ball Mills



Standardized Steam Generating Equipment for Central Stations

Foster Wheeler has demonstrated outstanding leadership in developing central station equipment which helped the Utility Industry to achieve increased productivity. A large share of the credit can be directly ascribed to the FW line of single-pass, baffle-less steam generators having liberal furnace dimensions. This arrangement has been used as the basis for "Preferred Standard" steam generator designs which have been developed by Foster Wheeler Corporation for the Utility Industry.

Engineering and Manufacturing Costs Reduced

The "Preferred Standard" steam generator design (suggested on the right) promises substantial savings by the reduction of engineering and fabrication costs.

Fixed Individual Equipment Details

The unit being built for the E. M. Poston Station of the Columbus and Southern Ohio Electric Company is typical of the single-pass design which Foster Wheeler is using as the basis for "Preferred Standard" steam generators. This standardized steam generator pattern with fixed individual equipment details may be readily applied to a series of single or twin furnace units varying in capacity from 300,000 lb per hr to over 1,000,000 lb per hr.

Other Foster Wheeler Fuel and Labor Saving Features

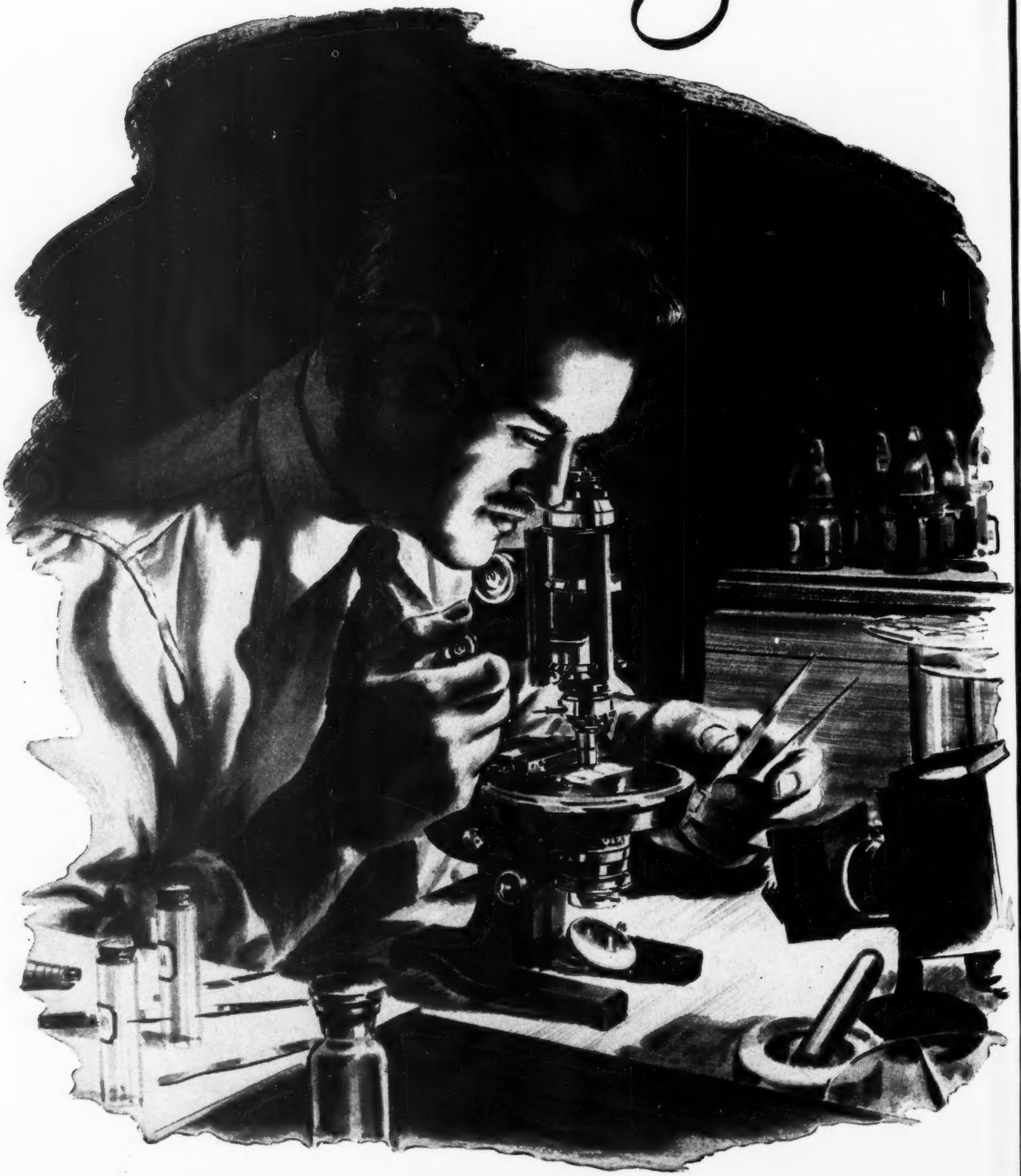
The design also embodies Foster Wheeler features of slag-free furnace arrangement, Foster Wheeler condenser-type steam temperature control, minimum baffles, low draft loss, and efficient heat recovery arrangement. When additional furnace cooling is required, the "Preferred Standard" design may readily incorporate a water cooled division wall.

For additional information, write . . .

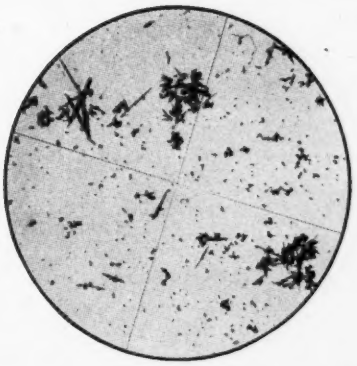
FOSTER WHEELER CORPORATION
165 BROADWAY, NEW YORK 6, N. Y.

FOSTER WHEELER

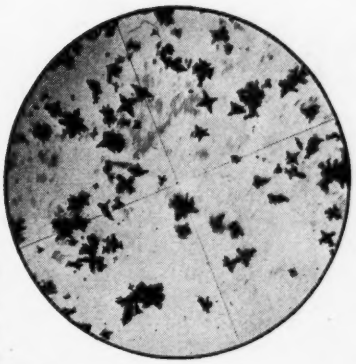
"Looking into



your boiler's past —to protect its future"



Above: Chemical test for copper—brilliant yellow needles and clumps.



Left: Similar test for zinc—white crosses.

There is nothing particularly dramatic in the appearance of the optical microscope—even the special polarizing type used in Hall Laboratories. Nevertheless, the microscope is one of the most important instruments for studying scales and sludges, in order to determine what has happened and what may happen in your boiler.

Microscopic examination of boiler deposits has several functions. In some cases, microscopic examination alone will give analyses sufficiently accurate for the purpose; in other cases this examination serves as a guide to the chemical analysis. When necessary, microscope examination and chemical analysis "team up" with other procedures to reveal facts which make it possible to determine the causes of boiler trouble and to prescribe remedies for them.

Many substances may be precisely identified under the microscope by their optical properties alone. When the crystals are too tiny for individual measurement, important information may still be obtained through microscopic observation of their reaction to various chemicals.

An example of this type of study is illustrated by the photographs on this page. If a zinc compound is present, treatment with the proper reagents will cause the formation of white dots which gradually lengthen to a cross. Finally the cross "feathers out," assuming the form shown in the photograph. Copper compounds react with the same reagents, giving yellow needles and clumps instead of white, feathery crosses.

These are only a few of the types of information which the microscope gives, and the microscope is only one of the many tools used by Hall Laboratories in its service to hundreds of plants, large and small, in all parts of the country.

Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pennsylvania.

HALL LABORATORIES, INC.

(A Subsidiary of Hagan Corporation)

CONSULTANTS ON
INDUSTRIAL WATER TREATMENT
HALL SYSTEM OF BOILER WATER CONDITIONING
INDUSTRIAL WASTE RECOVERY AND DISPOSAL

HAGAN
HALL
BUROMIN
CALGON

COMING... World's largest
for the world's largest steam-
.....in America's

Additional steam requirements at the world's largest steam-electric power plant—the Hudson Avenue Station of Consolidated Edison Company of New York, Inc. — will be supplied by the world's most powerful boiler — a B&W Radiant type unit now on order. It will have a continuous rating of 1,300,000 lb. of steam per hr. — 25 per cent more capacity than the next largest unit also on order at B&W for installation in the East River Station of the same utility. Steam will be generated in the new Hudson Avenue unit at 1675 psi and 1050F. It will be fired normally with pulverized coal from five B&W pulverizers through sixteen combination burners which can also be used for oil firing.

Perhaps the advanced engineering reflected in this outstanding unit can help you on present problems or future plans involving plant expansion.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.

GENERAL OFFICES: 85 LIBERTY STREET, NEW YORK 6, N. Y.
WORKS: ALLIANCE AND BARBERTON, O.; AUGUSTA, GA.

FOR POWER PLANTS—B&W, Open-Pass, Radiant, Integral-Furnace, Cross-Drum, Stirling and Waste-Heat Stationary Boilers . . . Air Heaters . . . Economizers . . . Superheaters . . . Water-Cooled Furnaces . . . Oil, Gas & Multifuel Burners . . . Chain-Grate Stokers . . . Stacks and Breechings . . . Seamless & Welded Tubes for All Pressure and Mechanical Applications . . . Refractories . . . Chemical Recovery Units . . . Alloy Castings.

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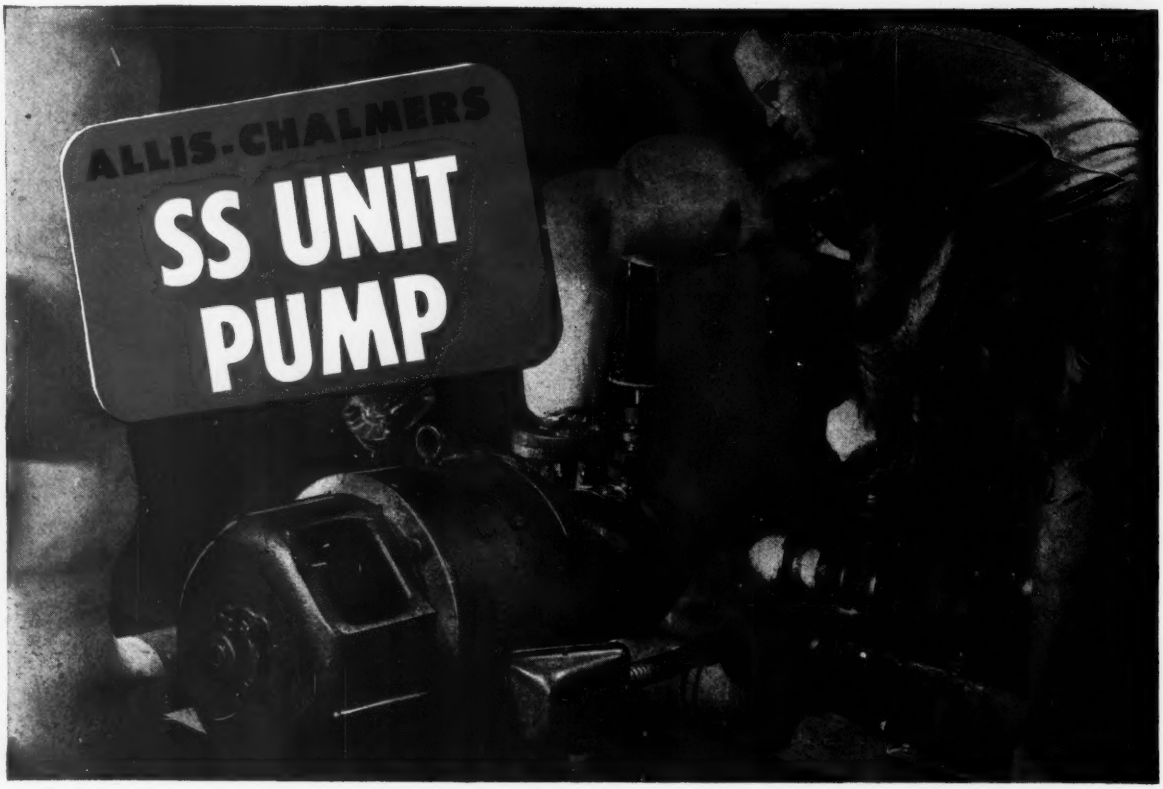
OTHER B&W PRODUCTS — Marine Boilers . . . Pressure Vessels . . . Process Equipment.

G-412T



50% MORE WATER
33% LESS POWER

"Our *old* displacement pump required 15 hp motor to raise 100 gpm 110 ft to roof tanks. Now this A-C SS Unit Pump Lifts 150 gpm to same tanks with only a 10 hp motor!"

THAT'S THE EXPERIENCE, along with worthwhile savings in space and maintenance, reported by the chief engineer of a large commercial building.

It is the kind of saving that you, too, may be able to make with Allis-Chalmers SS Unit Pumps. Here are 4 reasons why:—

Deliver Rated Efficiencies — Every unit tested at the factory and the performance curve plotted. Efficiency is proved.

Heavy Construction — Compare section thicknesses, shaft diameters and other features. See why SS Unit Pumps run years without repairs.

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SS Unit is one of many Allis-Chalmers models for most industrial pumping services. For information, see your Allis-Chalmers Authorized Dealer or District Office. Or write for Bulletin 52B6059E. Also listed in Sweet's. A 2595

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PUMPS — Integral motor and coupled types. Sizes and ratings to 2500 GPM.

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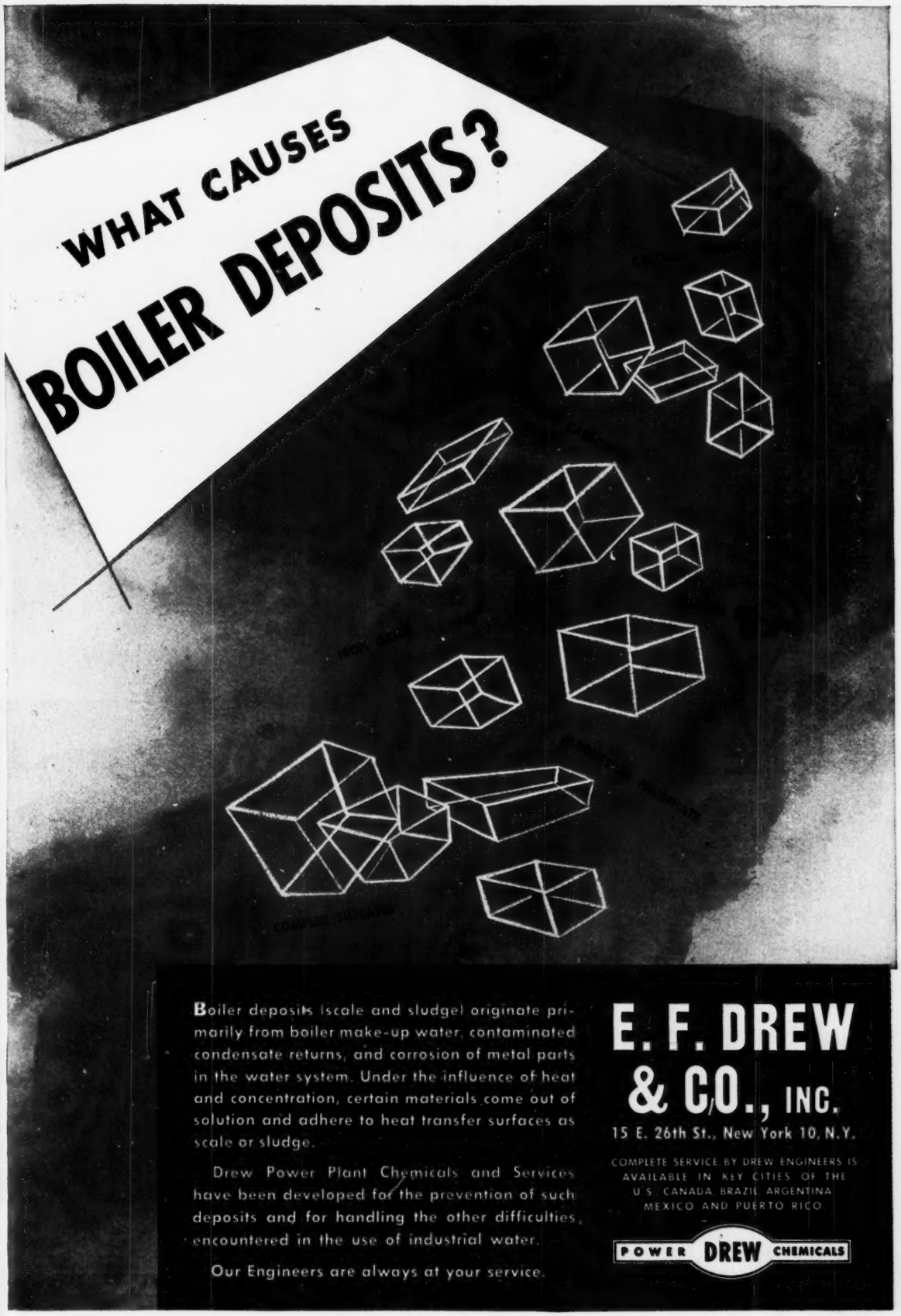

Boiler deposits (scale and sludge) originate primarily from boiler make-up water, contaminated condensate returns, and corrosion of metal parts in the water system. Under the influence of heat and concentration, certain materials come out of solution and adhere to heat transfer surfaces as scale or sludge.

Drew Power Plant Chemicals and Services have been developed for the prevention of such deposits and for handling the other difficulties encountered in the use of industrial water.

Our Engineers are always at your service.

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COMPLETE SERVICE BY DREW ENGINEERS IS AVAILABLE IN KEY CITIES OF THE U.S. CANADA BRAZIL ARGENTINA MEXICO AND PUERTO RICO

POWER DREW CHEMICALS

HAGAN controls a

AT ARTLOOM CARPET COMPANY, Inc.

When Artloom Carpet Company, Inc., Philadelphia rug manufacturers, needed increased factory space a few years ago, they decided to eliminate a stand-by boiler room. This was made practicable by modernization and expansion of the regular power plant.

The first step in the program was the purchase of a new boiler and necessary auxiliaries —and the immediate installation of Hagan combustion controls and Hagan Ring Balance instruments on the two old boilers so as to bring up their efficiency. Provision was made at the same time for centralized control of all boilers.

The Ring Balance Steam Flow-Air Flow Meters are of the indicating and recording type. Integrators automatically total steam flow from each boiler. A third pen records stack temperature.

On all three boilers, stokers and fans are turbine driven. Combustion conditions are regulated by direct speed control of stokers and fans. Rated capacity of the old boilers is 50,000 pounds per hour, of the new boiler 65,000 pounds per hour. There are load swings of as much as 30,000 to 35,000 pounds per boiler from the low at night to the peak demand when the dye shift begins work in the morning.

The controls and meters have given complete satisfaction, and have required no attention except routine maintenance since they were placed in operation.

For full information on Hagan Controls and Hagan Ring Balance Flow Meters, call the nearest Hagan representative or write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pennsylvania.

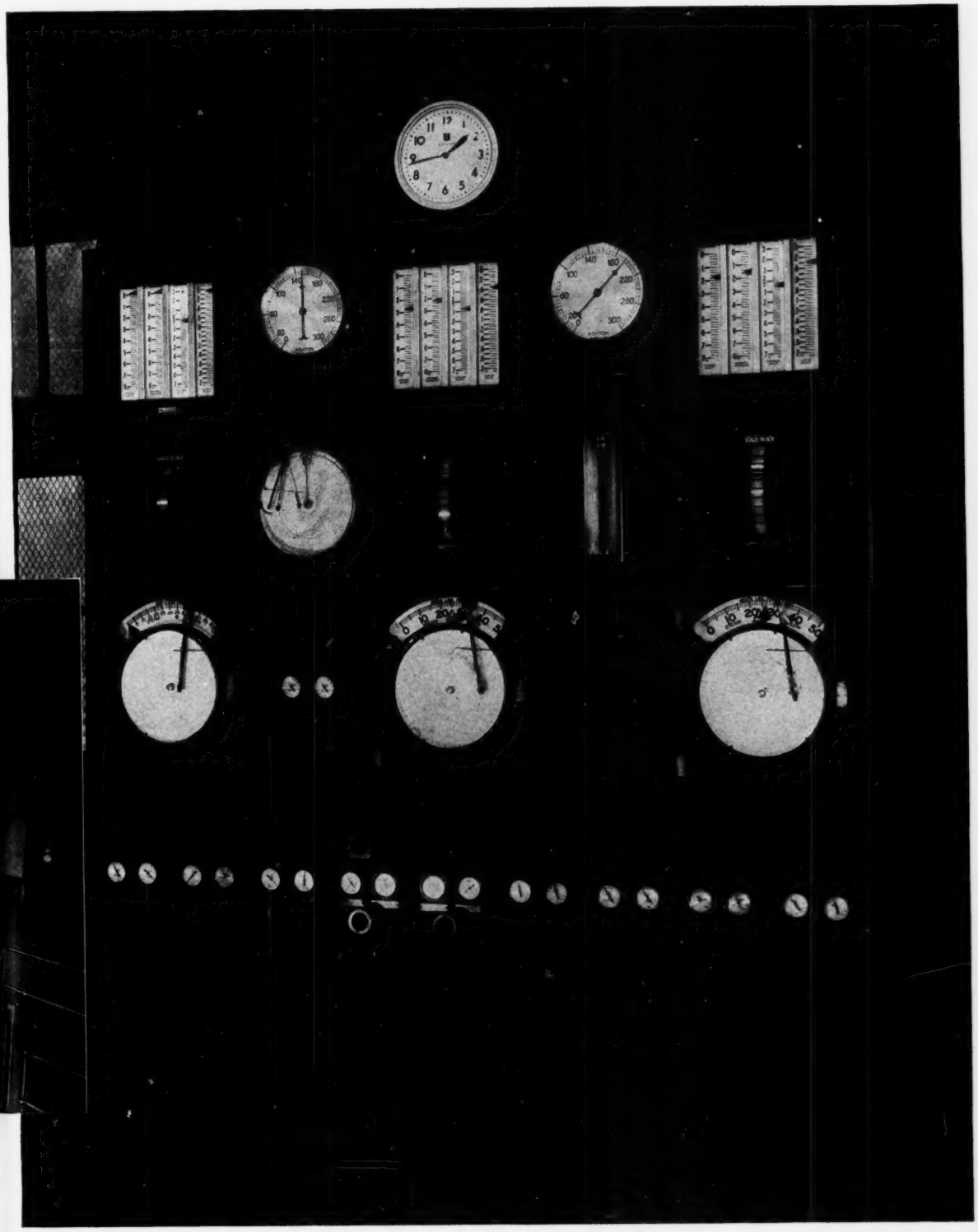
Above: Present boiler room at Artloom Carpet Company, Inc., Philadelphia. Modernization was planned and directed by Louis T. Klauder and Associates, consulting engineers. Otto Helbert, master mechanic, and Arthur Ingram, chief engineer, are in charge of the plant.

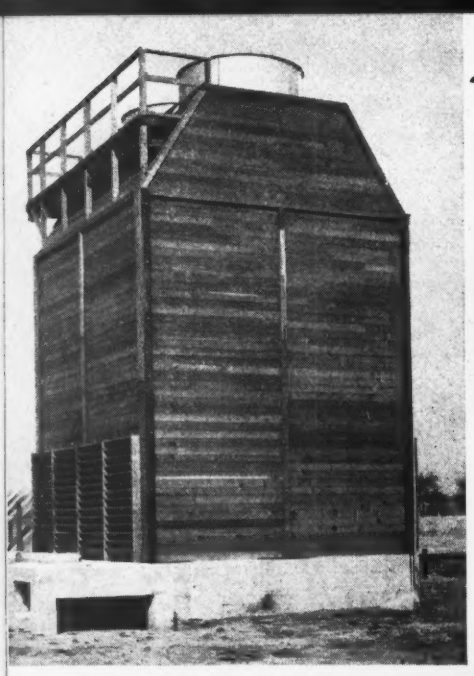
HAGAN HALL BUROMIN CALGON

HAGAN CORPORATION

BOILER COMBUSTION CONTROL SYSTEMS
RING BALANCE FLOW AND PRESSURE INSTRUMENTS
METALLURGICAL FURNACE CONTROL SYSTEMS
THRUSTORQ FORCEMEASURING DEVICES

sand meters





WATER COOLING TOWERS

Heavy Duty Construction, individually engineered for every installation. Interiors of redwood, with outside casing of wood, steel, transite or masonry to harmonize with building construction. Guaranteed water cooling performance and guaranteed to withstand hurricane winds up to 100 M.P.H. Send for Catalog No. 145.

C. H. Wheeler

Repeat Order for Dual Bank C. H. Wheeler Condenser At Hagood Station

After operating their original C. H. Wheeler "Dual Bank" Steam Condenser at Hagood Station for about a year, the South Carolina Power Co. ordered a duplicate, which is now under construction. They are both 20,350 sq. ft. surface condensers with a divided water box, which, of course, permits half the condenser to operate while the other half is being cleaned. "Dual Bank" tube arrangement gives a wide central lane with branches which permits deep penetration of the entering steam into the tube nests. Condensate temperatures and pressures equal those at the steam inlet; further, the high heat transfer closely approaches the theoretical "ideal" in overall efficiency. . . . Note the two C. H. Wheeler Circulating Water Pumps in the foreground; also the C. H. Wheeler Tubejet Air Ejector in the photo in the lower right, which is also a part of this Hagood installation. . . . Seven exact duplicates of this unit are installed in other plants. . . . Send for the Condenser Catalog No. 1461, which also describes Circulating and Condensate Pumps and Steam Jet Air Ejectors.

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Single and Twin Two-Stage Tubejets with Surface Inter-After Condenser for power plant use; also Two-Stage Tubejet with Surface Inter-After or After Condenser for replacing mechanical wet vacuum pump on existing "Wet Type" Surface Condensers. Catalog No. 1462 describes these and One- to Five-Stage Tubejets for process applications. Send for a copy.

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JECTORS • STEAM JET VACUUM REFRIGERATION
OF PHILADELPHIA

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COMBUSTION ENGINEERING COMPANY, INC.

and

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under the name

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PRODUCTS

For stationary and marine power plants

Complete steam generating units comprised of all types of boilers, fuel burning and related equipment for capacities from 1000 to 1,000,000 lbs. of steam per hr.

For railroads

Superheaters, steam driers, feedwater heaters, exhaust steam injectors and heater valves for steam locomotives. Steam generators for train heating

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Units for recovery of chemicals and waste heat

For process industries

Mills, pulverizers, air separators and flash drying systems for grinding, drying and separation. Pressure vessels, columns, towers, tanks

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Steam generators, separately-fired superheaters, gas generators, catalyst reactors

For municipalities

Flash drying and incineration systems for sewage sludge

For homes

Automatic gas and electric water heaters. Soil pipe.

The close association of Combustion Engineering Company, Inc. and The Superheater Company since their affiliation in 1933 has provided the opportunity for long and careful study of the advantages that might be obtained by complete merger under a single management. The fact that a major part of the activity of both companies involved the manufacture of different but related components of steam generating units prompted the taking of some steps in the direction of merger shortly after affiliation. The resulting experience led to a continuing program designed to bring about ever closer coordination of staff and operations. Thus the complete merger, which became effective on January 1, 1949, was but the final step in the unification of two organizations long experienced in working together to achieve common objectives.

The new company will continue all past activities of Combustion and Superheater, as summarized at the left, and will be able to offer the combined facilities and services of both organizations on a world-wide scale.

B-283A

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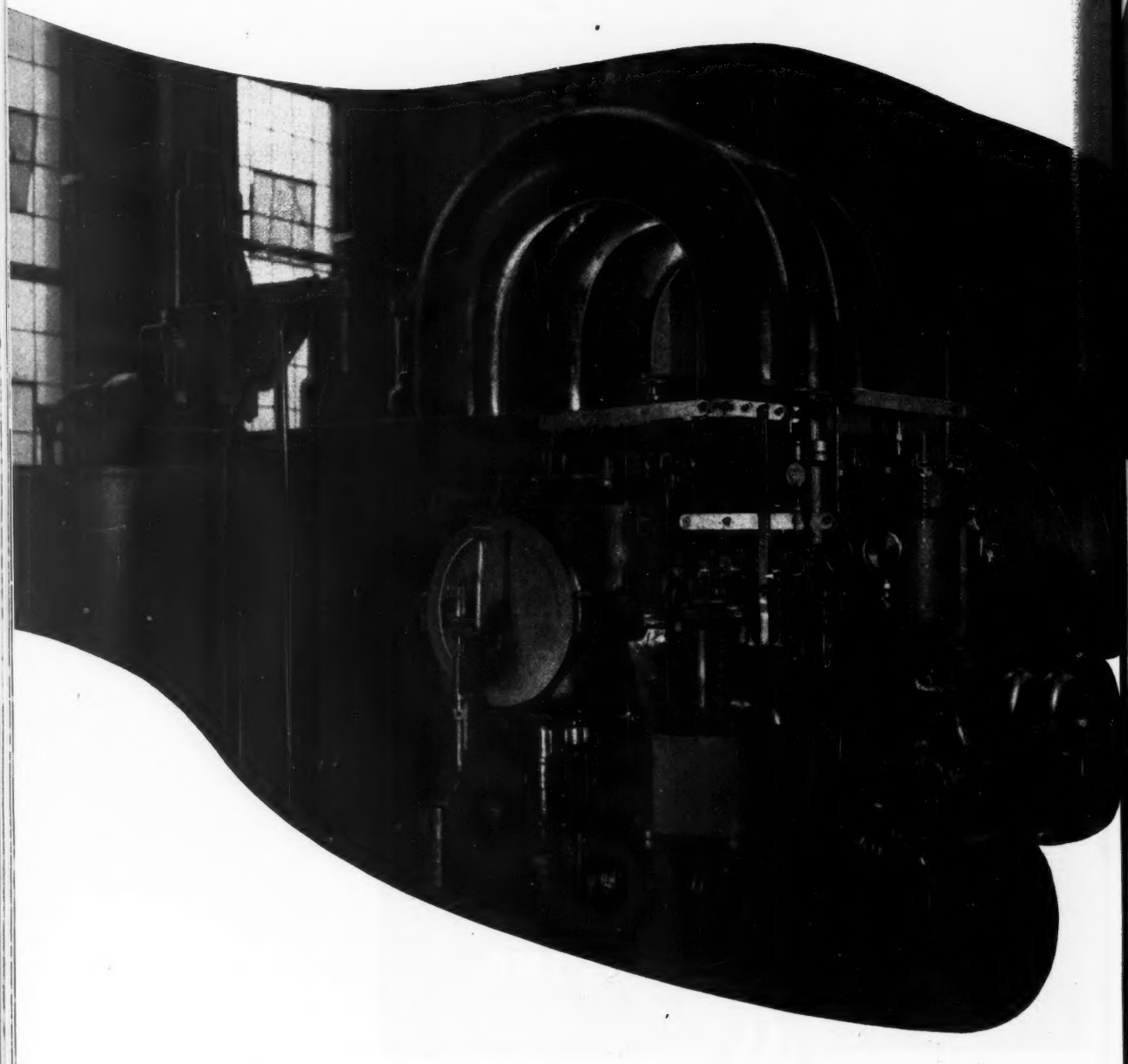
200 Madison Avenue, New York 16, N. Y.

RAILROAD EQUIPMENT DIVISION—60 E. 42nd St., New York 17, N. Y.



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"We guarantee that Nonpareil Turbine Oil, Medium and Heavy, will last as long as your turbine where the lubrication system is thoroughly cleaned before this oil is put into use and where Nonpareil Turbine Oil, Medium or Heavy only, is used for replenishment, and where the temperature of the oil from the bearings is kept below 170° F. This guarantee has no time limit. If at any time, when the oil is operating under the above conditions, the neutralization number should rise higher than the extremely low limit of 0.15 when determined by A.S.T.M. Method D 188-27 T, we will cheerfully replace the oil without additional expense."

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NONPAREIL TURBINE OIL

Under varying service conditions, one or all of these turbine oil qualities can bring added dependability to your turbine operation.

1. ***Nonpareil does not form asphaltic deposits.*** Delicate governor parts, oil lines, and bearings stay clean because the refining process removes from the oil all asphaltene-forming hydrocarbons.

2. ***Nonpareil does not increase in acidity*** above 0.15 mg.KOH/gm no matter how long it is left in a turbine. This is *guaranteed** in writing.

3. ***Nonpareil does not need treating, resting or replacing.*** There are no interruptions to turbine operation because of oil deterioration.

4. ***Nonpareil resists foaming.*** It contains an anti-foam additive which prevents oil overflow, eliminating a potential fire hazard or loss of oil.

5. ***Nonpareil contains a corrosion inhibitor*** and passes A.S.T.M. D-665-46T test for corrosion resistance.

20 years of operation prove that Nonpareil-lubricated turbines require no outage time for oil system maintenance. You can check this fact with nearby users of Nonpareil. A Standard Oil Lubrication Engineer will give you their names and locations. Write Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois for the nearest Engineer.

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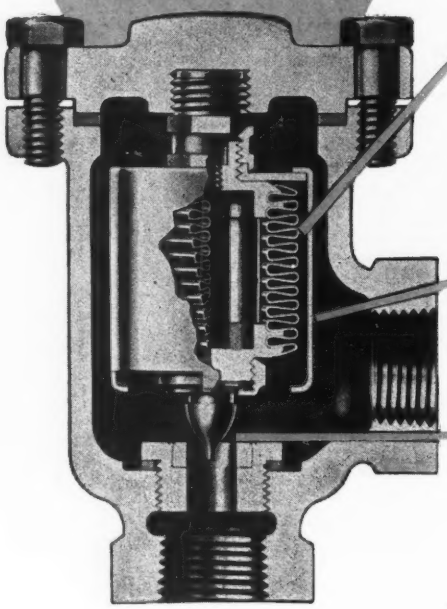
AFTER 25 YEARS STILL THE LEADER



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THERMOSTATIC STEAM TRAP

Sarco, the pioneer in high pressure thermostatic steam trapping, has maintained its leadership by producing ever better steam traps at ever lower costs. The know-how of designing and producing traps has been supplemented by extensive research with new materials, and constant additions of new machinery especially designed for us. And withall, every installation of the hundreds of thousands of these traps has added to the application data which is in the hands of every Sarco Representative.

FOR THESE VERY GOOD REASONS:

FAST ACTION Sarco No. 9 traps are filled to open at 10° F. below steam temperature. Wide open when cold, quick starts are assured. They are fast as well as efficient.

THE SARCO PHOSPHOR BRONZE BELLOWS is made in our own plant. We deep-draw the tubing from phosphor bronze blanks and corrugate it helically on special machines developed by us.

The result is a heavy wall bellows with extra strength to withstand unbalanced pressures, as on starting from cold. The end closures are brazed (not soldered) by the latest electronic induction methods. (Stainless steel bellows for corrosive condensate or superheat also are available.)

THE PATENTED SHIELD The shield which protects the bellows from abrasive action of the steam extends over the entire length of the bellows and forms a part of the element. Prongs at the end prevent over-expansion should the element be removed from the trap body while hot.

VALVE HEAD AND SEAT are of 18/8 stainless steel and renewable. The parabolic head is self-aligning to assure tight shut-off. Its shape secures maximum trap capacity with minimum valve lift.

REAL CAPACITIES ARE LARGE Sarco No. 9 uses a different diameter bellows for every trap size (except half inch). The 2" trap has a bellows 2⅜" o.d. It is the bellows area which determines the size of the valve orifice that can be used, and therefore the actual capacity.

TEST BEFORE YOU BUY. These features are vital to the trap user. They mean efficient condensate removal and long life with minimum maintenance costs.

Thousands of satisfactory installations prove the above statements. However, if you wish to make your own tests, we shall be glad to place at your disposal one or more traps of any desired size subject to return for full credit if they do not measure up to your requirements.

Full information in Catalog No. 250.

250

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SAVES STEAM

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The NEW Grinnell Pipe Hanger Manual

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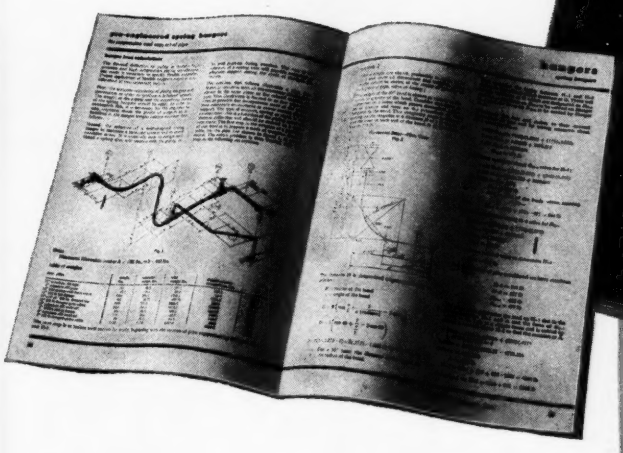

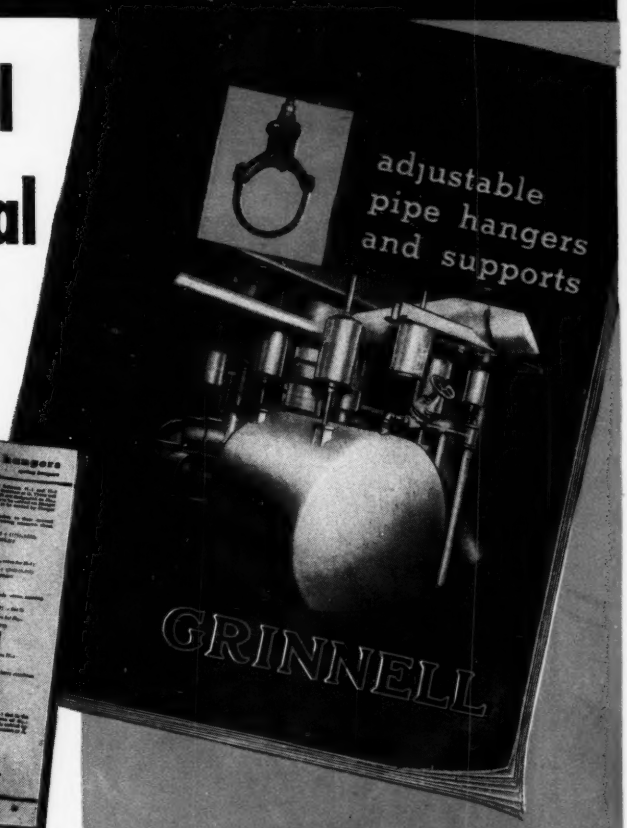

FIRST TIME . . . in one 92-page book every pipe hanger, part and accessory, with full instructions for easy selection and correct specification.

Grinnell engineers worked for months to put into one orderly, completely illustrated book everything you need to write hanger specifications precisely. It's a complete catalog of Grinnell Pipe Hangers and Supports and a comprehensive manual . . . all in one. It's worth money to you but it doesn't cost you a penny. Write for your copy today. Grinnell Company, Inc., Providence 1, R. I.

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- ★ How to make load calculations for spring hangers, step by step, with drawings
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- ★ A complete line of cast and malleable hangers ranging from the simplest plumbing or heating installation to the most complicated power plant installation

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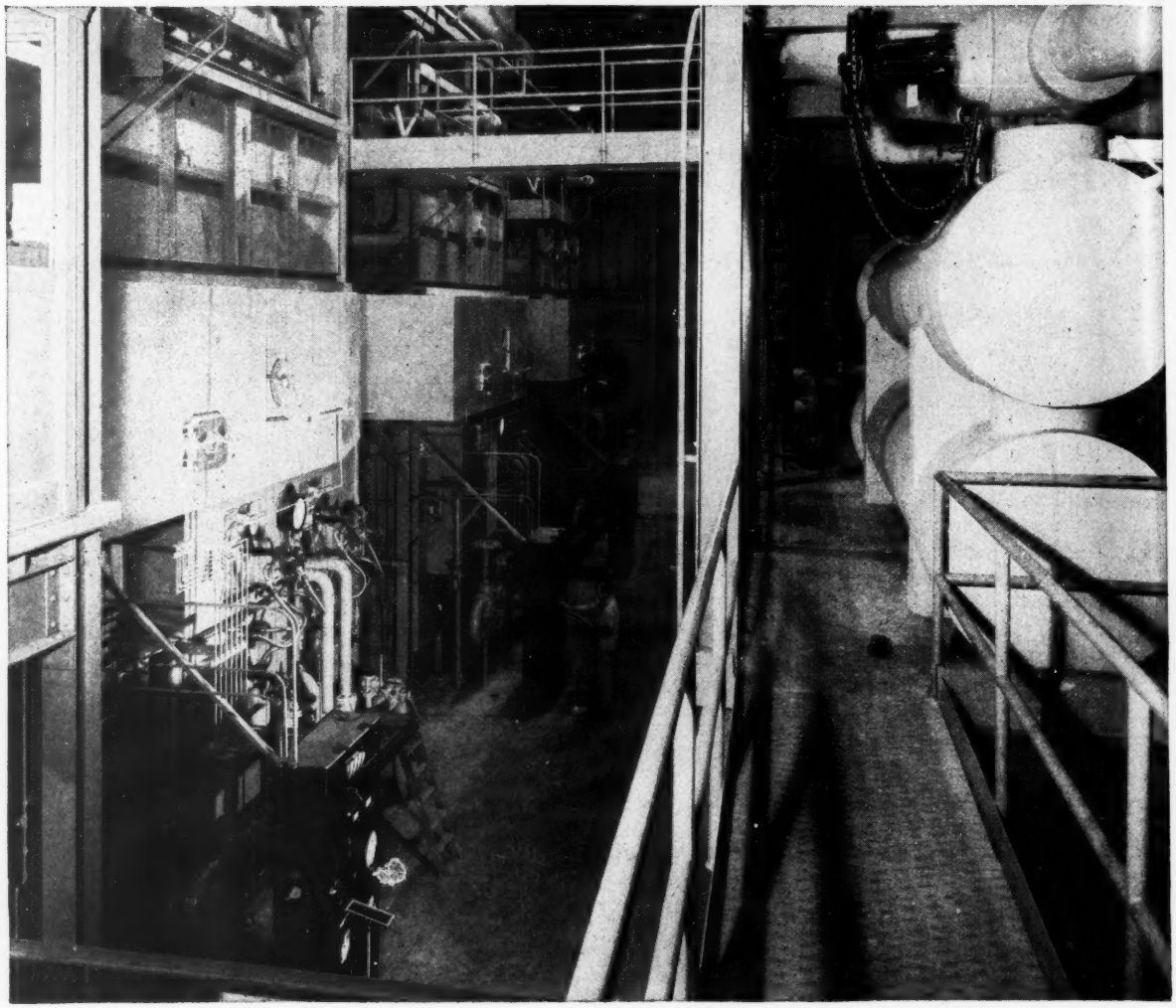
Today—More Republic



Interior view of a 400,000 lb. steam generating plant in a modern industrial plant. Steam is generated in these gas fired boilers which are operated by a Republic automatic combustion control system.

The installation of Republic automatic controls on your boiler (or boilers) will enable you to:—

SAVE FUEL by automatically maintaining highest combustion efficiency.

INCREASE STEAM OUTPUT by operating the boilers at test efficiency 24 hours a day, 7 days a week.

CONSERVE MANPOWER by automatically performing the many routine repetitive adjustments.

REDUCE OUTAGES by maintaining uniform operating conditions and thereby prevent the chain-of-event type of trouble that frequently develops as a result of incorrect boiler operation.

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INSTRUMENTS
AND CONTROLS

Combustion Control Systems

ARE BEING SPECIFIED THAN EVER BEFORE

because...

Built into the Republic combustion control systems are the many important features that enable it to fulfill all the conditions of theoretically perfect combustion control and still meet all the demands of everyday operation.

Check the following features against your list of "musts" when specifying a perfect combustion control system.

CENTRALIZED CONTROL:
The operation and control of the boiler or boilers is centralized at the master controller.

FUEL-AIR RATIO INDICATOR:
The master controller is provided with mercury manometers or gages which indicate the measured fuel and air inputs to the boiler and the fuel-air ratio.

FUEL-AIR RATIO ADJUSTMENT:
A handwheel on the front of the master control panel provides a convenient means for adjusting the fuel-air ratio.

FUEL VARIATIONS:
Automatically compensates for variations in fuel to maintain combustion conditions constant.

ALL BOILER RATINGS:
Maintains proper fuel-air ratio over the entire range of boiler ratings.

CONSTANT STEAM PRESSURE:
Maintains the plant steam pressure within narrow limits of variation by proportioning the fuel and air inputs to the load.

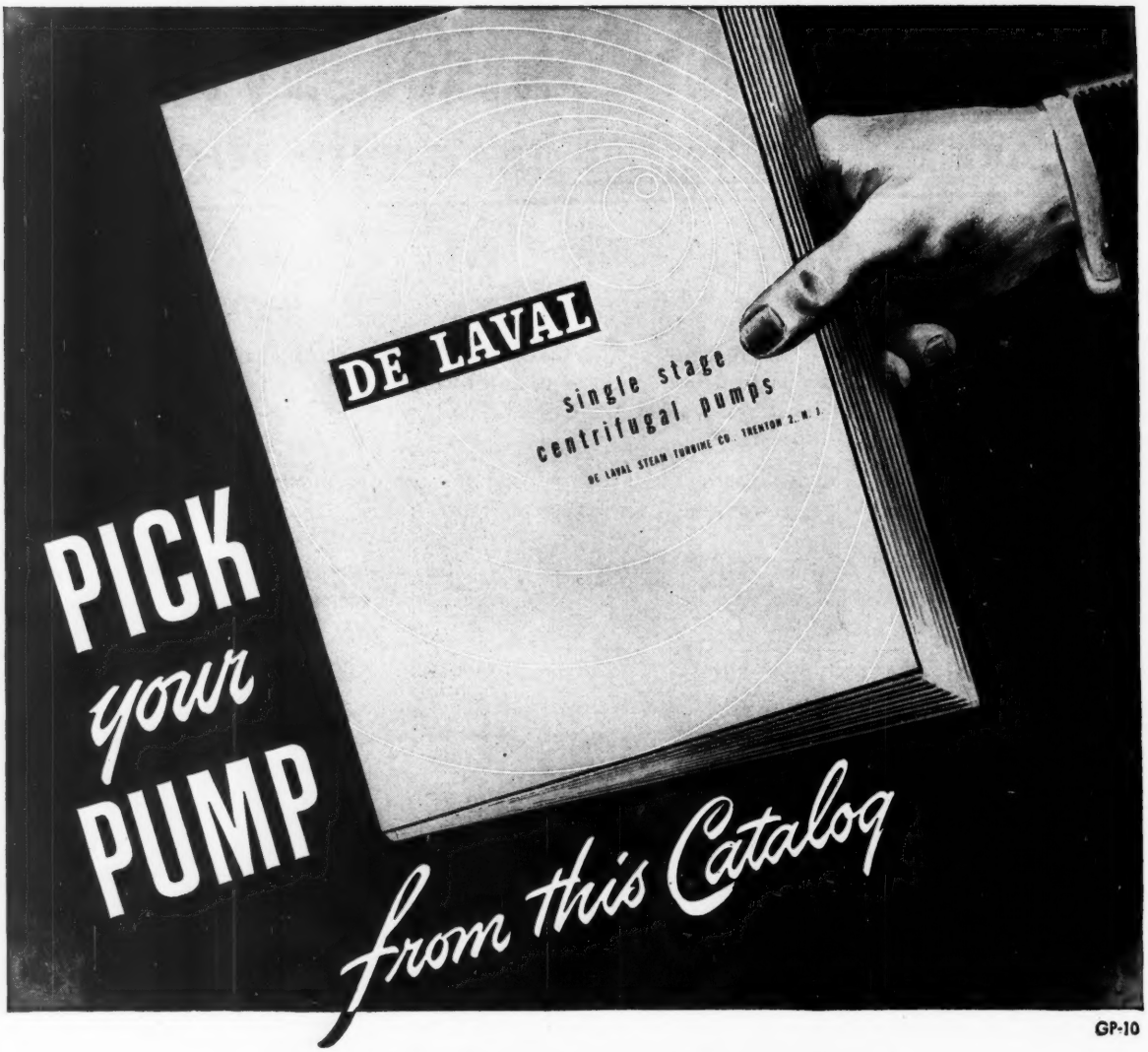
LOAD DISTRIBUTION:
Provides a means of distributing the load among the boilers as desired.

MANUAL CONTROL:
Boiler ratings can be controlled manually by a handwheel located on the front of the panel.

Find out about Republic control systems. One of our engineers will be glad to consult with you at any time without obligation on your part. Write us today.

Republic Flow Meters Co.

2240 Diversey Parkway • Chicago 47, Illinois



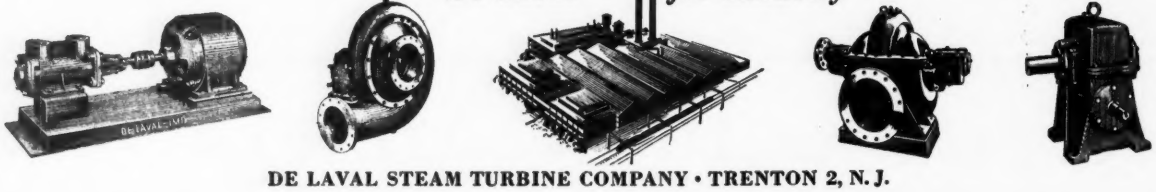
GP-10

COMPLETE WITH RATING TABLES AND DIMENSIONS

The text explains and illustrates features of design that you should look for when buying a pump. The simplified rating tables list pump and motor sizes for delivery and head requirements ranging from 150 gpm and 30′ head to 5000 gpm and 250′ head. The dimension drawings provide all information necessary for preliminary installation layouts. Ask for catalog GP-10.

DE LAVAL

De Laval for Industry



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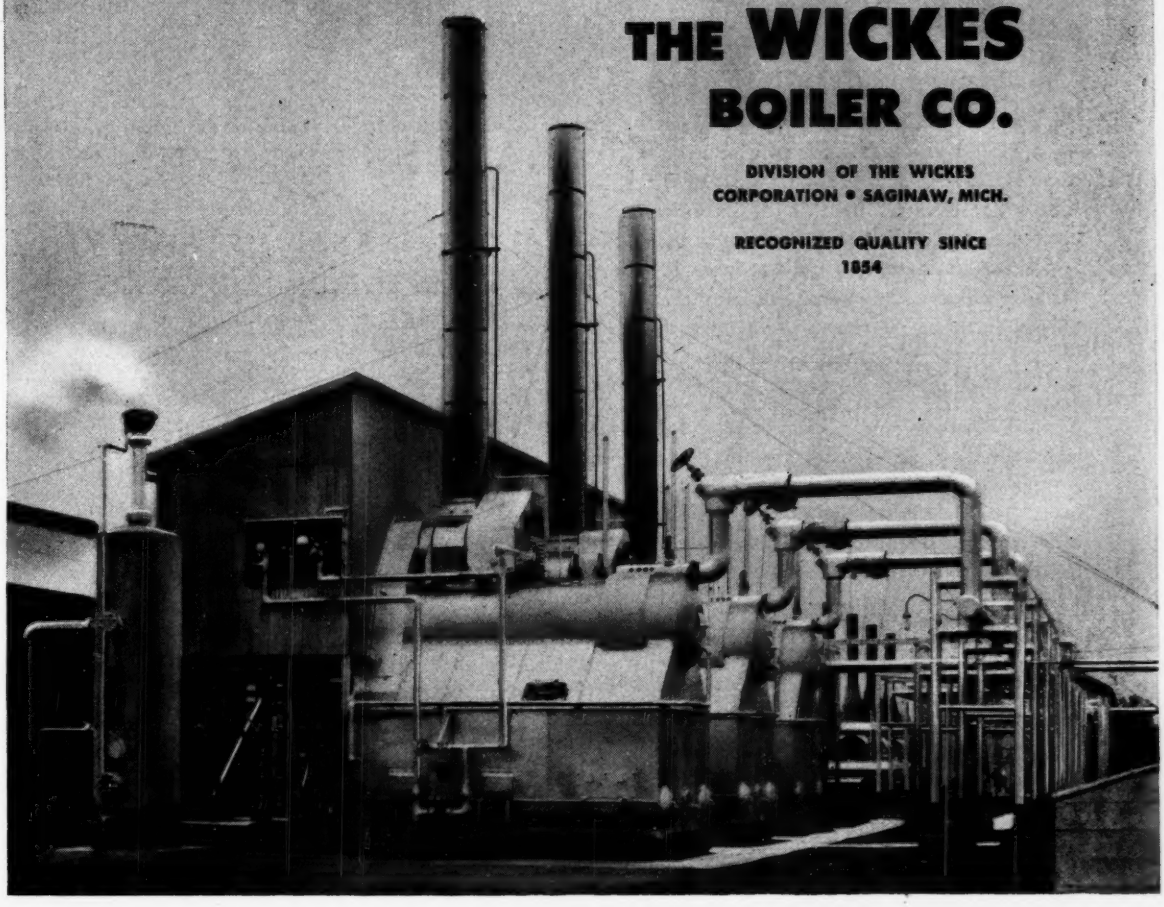
PETROLEUM PROCESSING SPEEDED WITH WICKES TYPE-A STEAM GENERATORS

Profitable processing of crude petroleum into fine oils and fuels requires the most efficient equipment available. These three Wickes Type-A water tube steam generators are operating in an oil field near Delhi, Louisiana. Wickes Package Type-A Steam Generators are compactly designed and efficiently engineered for immediate installation with least possible erection problems. Units are designed for pressures up to 850 psi, producing up to 200,000 lbs. steam per hour. Write for descriptive catalog.



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Cost Cutter for Users of

HOT PROCESS LIME-SODA SOFTENERS

Nalco $Na_2Al_2O_4$

SODIUM ALUMINATE

NALCO Sodium Aluminate — one of the many Nalco chemicals for effective water treatment — has special interest to users of hot process lime-soda softeners because of its efficiency and cost-cutting possibilities in most applications. Nalco Sodium Aluminate not only reduces hardness of softener effluent, but frequently cuts the need for phosphate after-treatment to such an extent that the savings on phosphate alone *more than pay for the $Na_2Al_2O_4$ used!*

Typical hardness and alkalinity analyses given at right serve to show what you may expect from properly applied Nalco Sodium Aluminate treatment. For details on the Complete Nalco System of Water Treatment for your plant, call your Nalco Representative — or write Nalco today.

Nalco chemicals are available in liquid, granular or powder forms, and in convenient 1-lb. ball briquets.

TYPICAL ANALYSIS WITHOUT Nalco SODIUM ALUMINATE

Total Hardness	Phenolphthalein Alkalinity	Methyl Orange Alkalinity
1.3 gpg.	2.5 gpg.	4.2 gpg.

TYPICAL ANALYSIS WITH Nalco SODIUM ALUMINATE

Total Hardness	Phenolphthalein Alkalinity	Methyl Orange Alkalinity
0.5 gpg.	2.0 gpg.	3.5 gpg.

NATIONAL ALUMINATE CORPORATION

6224 W. 66th Place • Chicago 38, Illinois

Canadian inquiries should be addressed to Alchem, Limited Burlington, Ontario

Nalco PRODUCT

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HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail

BOILERS, FURNACE WALLS

1 **Industrial Heat Enclosures**—Catalog C-46 is a 32 page paper bound booklet describing the company's line of complete furnace enclosures. The booklet starts off describing why anyone needs the company's products: Suspended Walls. Ease of maintenance is next covered followed by flexibility of design and ease of assembly. All of these sections are well illustrated and brief descriptions point out the advantages of the various types of construction. The booklet then continues by showing that only four basic shapes are required in the tiles which go to make up the walls. Typical installations are shown along with sectional drawings. Examples of air-cooled walls and insulated walls are presented. Other information includes the reducing of spalling through this particular design; standardized, emountable encasements; and a complete section on drum end seals described as "The Remedy for Air Leakage Thru Upper Side Walls." Other subjects covered include water wall backing, water wall support, simplified arch construction, arch variations and component parts, soaking pit covers, and many others. The entire booklet is well illustrated. Geo. P. Reintjes Co.

2 **Industrial, Commercial Boilers**—"Meet the Titusville Boiler Family," is a new 4 page bulletin featuring illustrations and engineering drawings of the company's line of industrial and commercial boilers. Steam generators and three and four drum water tube pressure boilers are shown in engineering detail drawings. One page illustrates and describes other available literature on specific types of the company's boilers. The Titusville Iron Works Div., Struthers Wells Corp.

3 **Water Tube Boilers**—This company's 4-drum water tube boilers are graphically illustrated in this new bulletin 3225-A. Engineering drawings and a 2 page spread showing front and side views of the 4-drum water tube boiler in engineering detail is accompanied by an easily read table of dimension and a typical performance curve. Also included in the new bulletin are engineering drawings showing special arrangements for fueling the boilers with bagasse, oil and coal. Titusville Iron Works Div., Struthers Wells Corp.

4 **Bonding Mortar Bulletin**—"Here's Where Savings Begin!" is the title of a new bulletin on high temperature bonding mortar. The bulletin tells representatives uses of the mortar, methods of application and use, general recommendations, packaging and storage, amount required. Outstanding advantages of the mortar are also listed. Walsh Refractories Corp.

ELECTRICAL

5 **Fan-cooled Motors**—Nine outstanding features of this company's totally-enclosed fan-cooled motors are described in Bulletin 05B7150. According to the bulletin, the problem of efficiently removing heat losses without exposing electrical parts to harmful atmospheric conditions has been solved in these motors, which are available in squirrel cage, wound rotor and synchronous types, for vertical or horizontal installations. Typical installations are shown by photographs. Allis-Chalmers Mfg. Co.

6 **Stationary Batteries**—Catalog GB-852 is a new 16 page catalog covering battery units for stationary service. Seven pages of the catalog are devoted to technical data and engineering specifications covering the 98 types in the company's line of stationary batteries. Capacities in ampere hours at standard and special rates, dimensions, weights and other data are tabulated in this section. The Gould Storage Battery Co.

7 **Switchgear, Control Devices**—Bulletin 25B7095 titled, "Switchgear and Control Devices," describes and illustrates rotary control switches, push button stations, generator voltage regulators, synchro-operators, current and potential transformers, oil and air circuit breakers and many other items. Types and ratings are supplied on the various equipment while standard wiring diagrams and photos of typical station combinations accompany the data on push button stations. Allis-Chalmers Mfg. Co.

8 **Separation Magnets**—A new 4 page illustrated bulletin F-2001 on separation magnets has just been announced. The bulletin gives detailed information on the application, construction, selection and suspension of separation and road sweeping magnets. It also contains detailed data on field attraction and penetration, magnet dimensions, weights and lifting capacities. The Ohio Electric Mfg. Co.

9 **Maintaining Insulating Oils**—Titled, "The Modern Way to Clean, Stabilize, Dehydrate and Degasify Transformer and Circuit Breaker Oils," this 4 page illustrated bulletin describes a self-contained unit which improves all dielectric to as high as 35 kv, prolongs oil service life and increases transformer capacity. Details of construction and case histories are included in the bulletin. The bulletin points out how volatile corrosive acids, air and moisture are removed, resulting in stronger resistance to sludging and emulsifying. Bowser, Inc.

10 **Permanent Magnets**—A new bulletin describing this company's high intensity perma-plate alnico magnet for removal of harmful tramp iron from food, chemicals, coal, feed, foundry sand and other materials, has just been issued. The bulletin, No. B-1205A, shows how the magnets can be installed in or above wood or metal chutes, ducts, pipes, hoppers, spouts, conveyor belts, and other places. Three types of magnets are shown: General Duty for farm and miscellaneous operations, Heavy Duty for most industrial applications and Extra Strong for difficult applications involving unusually heavy burdens or removal of large quantities of tramp iron. Dings Magnetic Separator Co.

HEATING, STEAM

11 **Steam Humidifiers**—Bulletin 1771 describes the company's steam humidifiers for automatically controlling relative humidity for the prevention of dry air damage to hygroscopic materials such as paper, leather, wood, cork, foodstuffs and other materials in storage or in process. The bulletin also describes the effect of relative humidity on human comfort and help and explains how maintenance of proper humidity will eliminate the fire and explosion hazards of static electricity where inflammable dust, vapors or liquids are present. Tables and charts are included on desirable relative humidity in various industries. Two useful sections of the bulletin are "How to Select," and "How to Install," both of which are accompanied by excellent line drawings presented in two colors. Armstrong Machine Works.

12 **Selecting Steam Traps for Unit Heaters**—This company has just issued an 8 page bulletin, Form 190, explaining how to select steam traps for unit heaters by the Btu rating method and the condensate weight method. Charts, tables and data in the bulletin include listings of the Btu outputs under standard conditions of all sizes of unit heaters produced by 24 different manufacturers; conversion tables for determining Btu output of unit heaters under varying conditions of pressure, temperature, entering air temperature and fan speed; and tables showing recommended sizes of the company's traps for draining unit heaters of given Btu capacities. Recommended installation diagrams are also included. Armstrong Machine Works.

13 **Tubular Heat Exchangers**—Bulletin 916 is a particularly informative 32 page bulletin which has just been issued. The bulletin describes the present designs of the company's tubular heaters, coolers, condensers and heat exchangers and their distinctive features. The various types of shells, tube bundles, stationary heads and floating heads are fully explained, together with statements of the particular services for which each is suitable. An additional helpful feature of the bulletin are tables of the characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and degrees API. Also presented is a chart of the specific heats of midcontinent crude oils and the charts for solving the MTD formula with correction factors for other than countercurrent conditions. The Griscom-Russel Co.

INSTRUMENTS, CONTROLS

14 **Resistance Testers**—Included in this new Bulletin 21-20-54 are clear and easily understandable descriptions of the Megger heavy-duty insulation resistance testers and accessory features with ample illustrations, charts and diagrams. Hand-driven, motor driven and multi-voltage instruments, their features, ranges and applications are detailed in a manner which should simplify the selection of proper instruments for specific insulation resistance measuring problems. James G. Biddle Co.

15 **Pressure and Vacuum Gauges**—This new catalog 7000 describes the full and complete line of instruments such as indicating and recording pressure gauges, recording flow meter and pressure gauge, air operated controller, non-indicating pressure controllers, indicating furnace

FEBRUARY, 1949

POWER GENERATION

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pressure controller, precision pressure regulator, etc. Also featured in this catalog are pressure actuating elements, high vacuum gages and other items. The catalog is well illustrated throughout its 31 pages with clear schematic drawings, photographs and diagrams, and also presents pressure range charts and indicating scales. The Brown Instrument Co.

16 **Temperature Measuring Instruments**—For all those responsible for the safe operation of electric power equipment, this company has just issued a revised 34 page catalog ND4-33-461 describing the company's instruments for measuring the temperature of generators, motors, condensers, transformers, etc. The bulletin covers a wide variety of instruments, portable and automatic indicators, for checking in any order on temperatures. Reference also is made of new and specialized instruments for measuring in rapid succession a number of bearing temperatures. Leeds & Northrup Co.

17 **Insulation, Resistance Testers**—Bulletin 1248 describes this company's line of Megohmer insulation and resistance testers. The booklet presents complete specifications and also shows photographs of each item in the line and on the back page of the four page folder, it shows a supply of "Megographs" which are furnished free with all Megohmers. Herman H. Sticht Co., Inc.

LUBRICATION

18 **Air Compressor Lubrication**—This is the Second Edition of this excellent handbook on Air Compressor Lubrication. The booklet contains 40 pages and starts off with a description of various makes of air compressors complete with cutaway views of the unit for both stationary and portable compressors. The book has been broken into logical sections, such as intercoolers and aftercoolers, air receivers, rotary compressors, turbo compressors, lubricating systems and compressor oils. One complete section deals with the lubrication of the running gear. A chapter on operating hints and oil requirements of air cylinders is included. The entire booklet is exceptionally well illustrated and will prove to be a handy reference handbook for engineer's library. Cities Service Oil Co.

19 **Clean Oil**—The latest issue of "Clean Oil" tells how the company's oil purifier does a good job for Kaiser-Frazer, Chefford Master, Boston Towboat Co. and Omaha Public Power District. Descriptions of the various ways in which the purifiers are used in these plants are given and drawings and photographs illustrate the stories. Honan-Crane Corp.

MATERIALS HANDLING

20 **Storage Rack Systems**—A proved means of substantially increasing the actual capacity of available storage space without new construction is presented in this Bulletin 4873. The booklet is profusely illustrated with installation views of barrel and drum racks and skid racks, showing how storage capacity has been multiplied several times in various establishments by utilizing overhead space efficiently. Line drawings show how large amounts of floor space are rendered available for production operation after the racks are installed. The bulletin contains full information on the characteristics of the storage rack, including arc welded steel construction which provides maximum strength without excessive bulk or weight, easily adjustable runners and other features that facilitate handling. Barrett-Cravens Co.

21 **Continuous Weighing of Dry Materials**—Bulletin E4-550 describes the company's new meter for continuously weighing and totalizing the flow of dry materials on conveyor belts. The meter can also be used for the automatic proportioning and controlling of dry or liquid feeders for secondary ingredients. The bulletin describes how the device operates, how it is constructed and gives various features. A double page spread, printed in two colors, presents a typical installation of the unit on a belt conveyor. Blueprint type drawings illustrate various applications for the continuous weighing and/or controlling and proportioning and flow of dry or liquid materials. Builders-Providence, Inc.

22 **Inspection and Care of Chain**—This new booklet titled, "Inspection, Care and Use of Alloy Steel Chain," includes a check list of things to look for when inspecting chain in your plant; factors that enter into and govern the proper use of chain; a plan for assuring your chain the necessary care; a table giving the maximum wear limits for each diameter of chain; the safe working load limits of each size of chain and the correct methods of repairing. S. G. Taylor Chain Co.

PUMPS, COMPRESSORS, ENGINES

23 **Pumps, Condensers**—This bulletin is a condensed catalog of the products, plants, facilities and services of this company. A concise description of the services offered by nine divisions of the company are presented in the bulletin and a summary of the combined services and products offered by the various units is given on one page. A listing of the general maintenance service and bulletins and catalogs which are available to the company also are presented. A handy cross-index of products in industries served is given in an exceptionally useful cross-indexing chart which occupies a full page. Condenser Service and Engineering Co.

24 **Centrifugal Pumps**—Form 4301J describes the company's single stage, enclosed impeller, ball bearing, belt and motor driven centrifugal pumps. Sectional views of the pumps accompany materials of construction tabular listings, along with pages of specifications and performance charts. Performance selection tables assist in selection of the proper units. The last page of the 8 page booklet is devoted to dimensioned line drawings and tabular material. Gould Pumps, Inc.

25 **Pump Maintenance**—Metallizing saves money in the maintenance of pumps according to the new easy-to-read November issue of "Metco News." To help the readers solve their pump maintenance problems, this issue shows the savings possible by metallizing a wide range of pump parts, both centrifugal and reciprocating. It tells how owners of metallizing equipment are restoring such pump parts as shafts, hubs, rods, plungers, pistons and sleeves. As an example, one user of metallizing reports savings of $2475 in one year. Metallizing Engineering Co., Inc.

26 **Flexible Tubing for Diesel Installations**—Bulletin 71 is an 8 page booklet which describes the various flexible metallic tubings for use with Diesel installations on fuel lines, air lines, oil lines, water lines and exhausts. Tables of characteristics for the various types of tubing are presented and the various types also are illustrated. Pennsylvania Flexible Metallic Tubing Co.

27 **Steam Engine Governor Data**—This new bulletin No. 502, describes the company's Type EN fully enclosed self-lubricated governor which is described as giving "precise, dependable engine speed control." Illustrations of the unit are presented and a parts list, accompanied by a sectional diagram is given. One section "Installation and Care" tells how to assemble governor to engine cylinder and how pulleys should be proportioned, the proper type of belt for use with the governor, correct lubrication procedure, method of packing and other data. Troy Engine & Machine Co.

STOKERS

28 **Better Stoker Control**—Bulletin 1022 describes the company's air operated control for spreader stokers. Illustrations of each of the parts of the control are given and a line drawing shows the complete combustion control applied to a boiler fired by a spreader type stoker. Bailey Meter Co.

29 **Underfeed Stokers**—This 8 page bulletin No. 1008-A describes the company's Commercial Type Series 40 anthracite and bituminous underfeed stokers for use in heating clubs, hotels and other institutions, small factories, warehouses, greenhouses, office buildings, etc. Complete description of the unit is given and one section tells how it operates. Fourteen outstanding construction features of the stoker are listed on a double page spread and are accompanied by an excellent cutaway installation drawing. Drawings and tables of sizes and capacities for both the anthracite and bituminous stoker are given. Typical installations are shown in line drawings. Flynn & Emrich Co.

30 **Stokers and Grates**—This small bulletin presents photographs of various parts of the hand fired and the mechanical equipment for burning all solid fuels that is manufactured by this company. Brief descriptions are given. The McClave Co.

WATER TREATMENT

31 **Antifoaming Compound**—This new technical bulletin covers the company's latest products known as Antifoam 8. With the accelerated rate of operation in many power plants today, foaming from either chemical or mechanical origin has become one of the prime problems in boiler operations. This technical bulletin presents reasons for foaming and deals with the chemical causes, especially the application of antifoams to elimination of carryover from these causes. After discussing the causes for foaming the bulletin goes on to describe the proper dosage and feeding and results obtained from the use of Antifoam 8. E. F. Drew & Co., Inc.

32 **Removing Oxygen from Boiler Feed Water**—The treatise on the importance of removing oxygen in order to keep boiler corrosion down is presented in this new technical bulletin No. 0-26. A problem is presented and a description of mechanical and chemical means for removal of oxygen are given. The bulletin then tells what Santosite is and the principle of the Santosite treatment; how Santosite is applied and the necessary operating procedure. Among the sections are How Much Santosite is Required; Cost of Santosite Treatment; Packing and Shipping; Determination of Santosite in Treated Water; and a complete Bibliography. Monsanto Chemical Co.

33 **Slime and Algae Control**—Technical Bulletin No. 0-15 describes Santobrite a chemical for the control of slime and algae. The bulletin tells about the importance of controlling micro-organism growths which clog water passages in most cooling water systems and describes the

(Continued on page 134)

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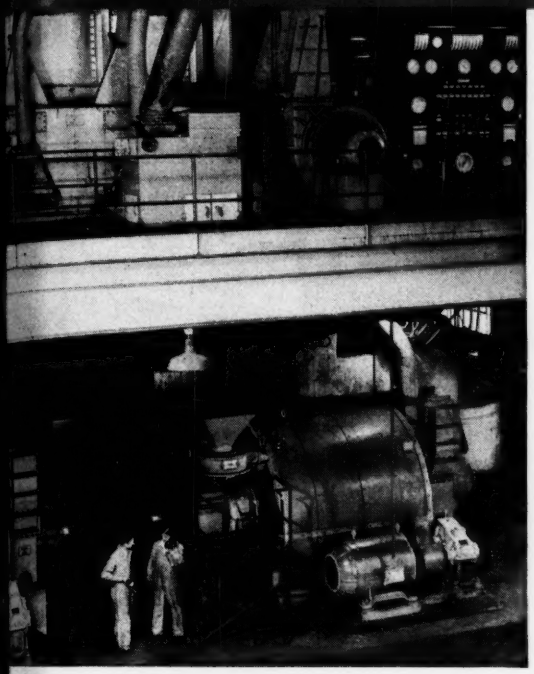

How much POWER can Dowell Chemical Scale Removal Service Restore for you?

Power engineers have found in Dowell's *chemical* scale removal service a modern method for *restoring power*. They know that more efficient operation of boilers, condensers and other heat exchange equipment has been achieved after removal of the insulating scale and sludge deposits by this tested service. They have seen for themselves how effective Dowell's service really is.

Dowell engineers treat your equipment with liquid solvents designed to dissolve and disintegrate the accumulated deposits which retard heat transfer. They are experienced in practical methods, know which solvents to use, and bring with them special truck-mounted tanks, pumps, mixers, heaters and control equipment.

Dismantling and down time are held to a minimum in Chemical Scale Removal Service. The solvents are pumped into the equipment through the regular connections. The most complicated heat transfer equipment has been cleaned effectively by Dowell solvents which reach wherever steam and water flow.

Call or write the office nearest you for a free estimate of the cost of cleaning your boilers, condensers, heat exchange equipment, water lines—and for increasing water well output.

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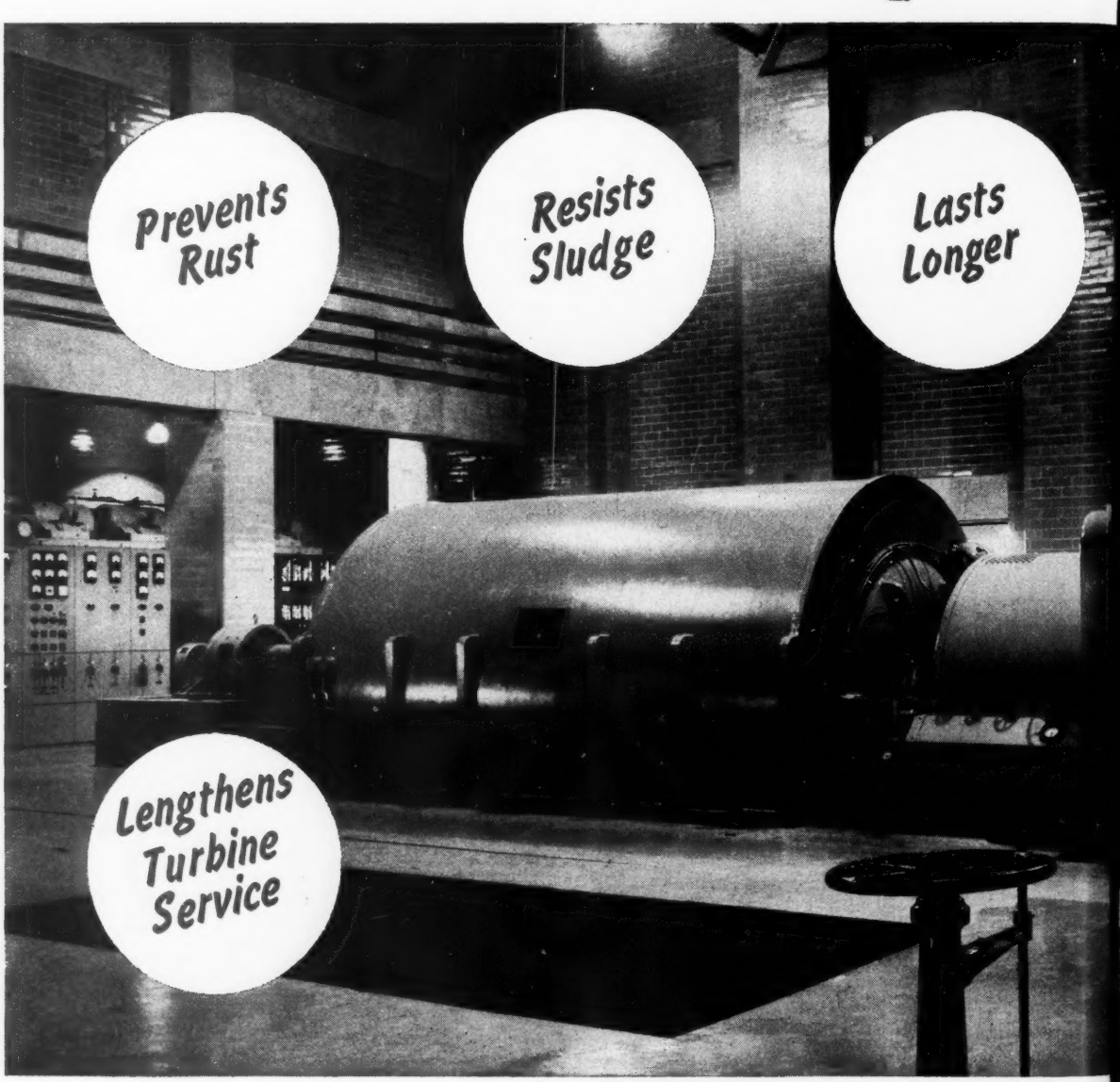

SINCLAIR

YOUR NEAREST SINCLAIR AGENT WILL GLADLY ARRANGE

Oxidation To Give Steam Turbine Service

One of the problems in steam turbine operation is the build-up of acidity in the lubricant due to oxidation. This causes harmful sludge to clog passages and impair the proper functioning of the governor.

This problem is solved when Sinclair SINTURLITE OILS are used. SINTURLITE OILS are fortified to resist oxidation and resultant acidity, retarding the formation of sludge. Other additives protect against rusting. The system is always clean, including the oil lines, bearing clearances and intricate governor mechanism. Try Sinclair SINTURLITE OILS.

Continual research explains the high quality of SINTURLITE and other Sinclair Oils. Sinclair has recently completed at Harvey, Ill., one of the most modern and complete laboratories for petroleum research and development.

E. W. Isom, Sinclair Vice-President in Charge of Research says: "With the new facilities now made available to us at Harvey, Ill., we expect to find many ways to help industry cut costs through better petroleum products."

INDUSTRIAL OILS

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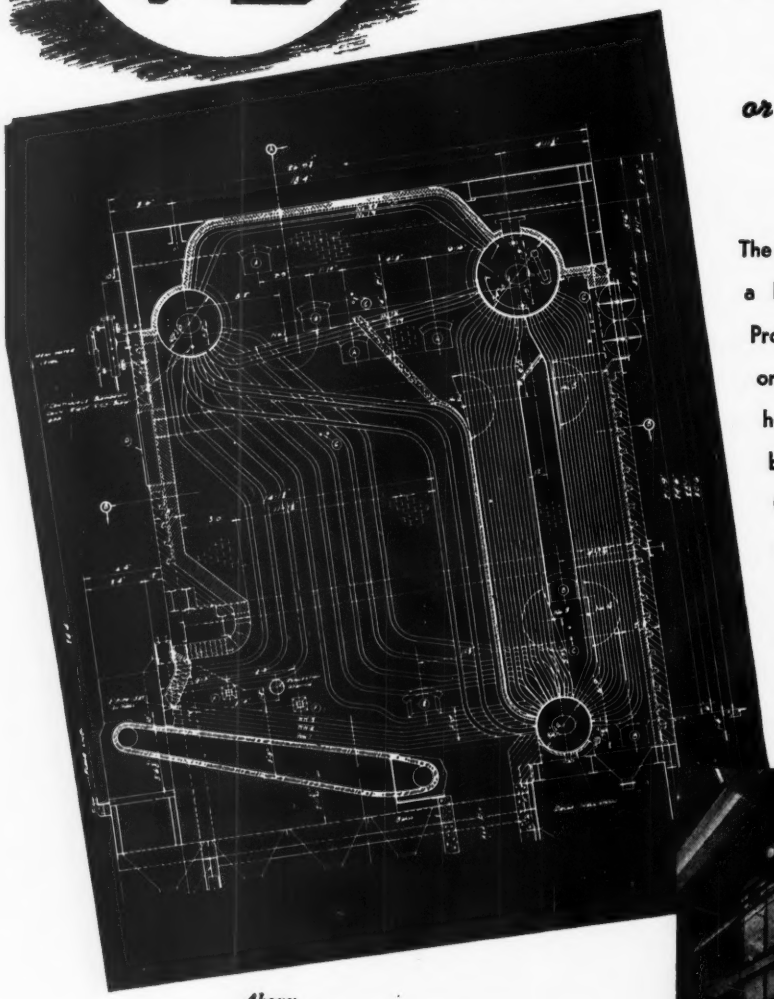
CLASS **VL**

Vogt

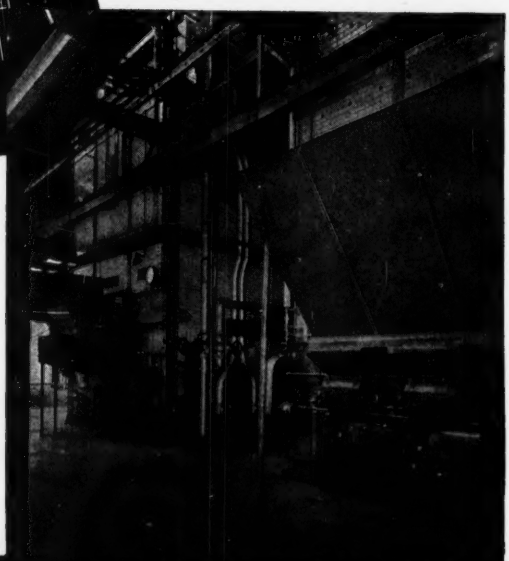
Steam Generating Units

for POWER *or* PROCESSING LOADS, *and* HEATING

The design provides large furnace volume and a high ratio of radiant heating surface. Proper combustion is assured with any fuel or method of firing. Superheaters, air preheaters, economizers, water walls, and soot blowers can be readily incorporated. Vogt Class VL Steam generating units are giving satisfactory service in Hotels, Sugar Refineries, Steel Mills, Furniture Factories, Distilleries, Oil Refineries, and related industries. A bulletin showing typical installations will be sent upon request.



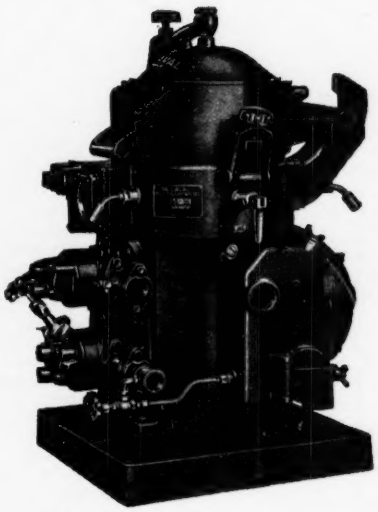
Above:
This 90,000 lbs. steam per hour unit, designed for 475 lbs. pressure, serves the Mansfield Tire & Rubber Co., Mansfield, Ohio.



Right:
Two 515 H.P. units installed in Brown-Forman Distillers Corporation, Louisville, Ky. Plant.

HENRY VOGT MACHINE CO. • 1000 W. Ormsby St., Louisville 10, Ky.
Branch Offices: New York, Philadelphia, Cleveland, Chicago, St. Louis, Dallas

I KEEP OUT DIRT and WATER



"I am De Laval Centrifugal Force. When I am put to work to purify lubricating oil — either turbine lube or Diesel lube — I do more than just remove the ***dirt*** present in the oil. I take out ***water,*** too!"

That's where De Laval Centrifugal Force differs from other means of maintaining lubricating oil. It does its job ***completely***—the protection it affords against trouble from impurities remaining in lubricating oil is ***complete*** protection. No half-way measures for De Laval Centrifugal Force — the water is discharged continuously after being centrifuged out, and the dirt is stored outside of the zone where purification takes place.

De Laval Oil Purifiers have another advantage — enough reserve capacity to take care of a sudden emergency, such as a surge of water due to a leak.

Write for additional information.

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THE DE LAVAL COMPANY, Limited, Peterborough, Ont.

DE LAVAL

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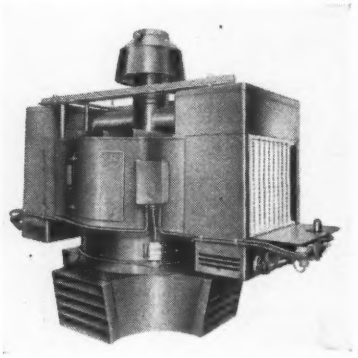
Use the coupon below when you want further information on the equipment described on this page and following pages. Write the identifying letter or letters in the space provided, clip the coupon and send it to Power Generation, 53 West Jackson Boulevard, Chicago 4, Illinois

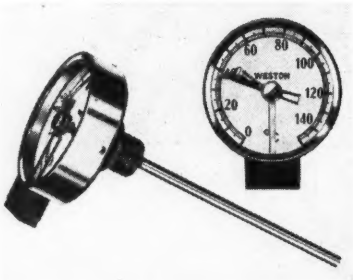
A Unit Heater. A new, self-contained gas-fired revolving unit heater, using either natural or manufactured gas has been announced. The heater combines gas burners, heat exchanger and combustion chamber with a motor-driven fan and revolving discharge outlets. Designed for overhead location, it projects the heated air to the working level and by means of the revolving outlets circulates the warmth



in all directions, under obstacles, into pits, and reaches into the furthermost corners.

Even in the summer these heaters are at work, but here they become a cooling device by simply turning off the gas and turning the fans on. The air is circulated in the same manner as the heated air in the winter. The unit heater is described as a ruggedly constructed piece of equipment. L. J. Wing Mfg. Co.

B Contact-Making Thermometer. A new contact-making thermometer, combining the features of an indicating thermometer in addition to an alarm or control device, has been introduced.



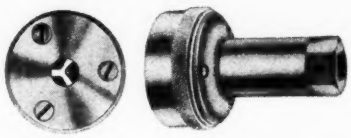
The instrument consists of an all metal thermometer with an adjustable contact arm mounted in the glass and bezel as illustrated. A screw-type terminal block mounted on the periphery of the case front provides for effective electrical connection. Contacts are of the magnetic type which assure positive action during making and breaking of the contacts. The contact arm is easily set to make contact at any temperature over the entire scale, and while contact can be broken manually after an alarm has been sounded, the contacts "break" automatically on a temperature change of about 5 per cent.

The thermometer can be supplied to make contact on either increasing or decreasing temperature. The accuracy as an indicating thermometer is ± 1 per cent; and as a control device ± 1 per cent of the full scale range. The instrument is available in stem length from 2½ in. to 24 in., with longer stems available on special order. Weston Electrical Inst. Co.

C New Stud Puller. A new design stud puller with a capacity of ¼ in. to ½ in., built in one unit with no collets, wedges, or other parts needed to adjust it to different sizes of studs in its size range has been announced.

To operate, turn the knurled collar to "in" for replacing or "out" for removing, and slip over the stud. Then insert a ½ in. square drive handle and pull. The three jaws automatically close to stud size and grip when pressure is applied. The harder you pull, the harder they grip; but they never wedge. They "bite in" but never stick. Release the pressure and the jaws release, ready for another "bite." This feature gives the A-80 a "built in" ratchet action for operation in close quarters. No ratchet wrench is necessary.

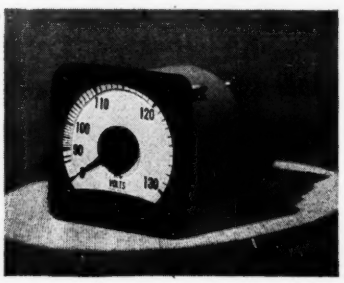
Because the grip is in the exact center, the tool turns on center. This means that the 2⅜ in. face will turn in just that diameter. You can "pull" a ½ in. stud with less than 1 in. clearance between the stud and surrounding obstructions. It will operate equally well



on long or short studs. Just ½ in. protrusion of the stud is necessary for proper operation, and no stud is too long. While the tool is only 3½ in. high, longer studs can run out of the handle hole and the stud puller can then be turned with a Boxocket or open end wrench by means of the 1 in. hex milled on the top. Snap-on Tools Corp.

D Expanded Scale Voltmeter. A new indicating voltmeter with an expanded scale has been announced as an addition to the Type AB-15 line.

Designed for general switchboard use by electric utilities and large industries, the new meter has a scale 7.1 in. long sponning 250 deg about the center. The scale is expanded over the most frequently used range, from 90 to 130 v, thereby enabling easy detection and measurement of 0.5-v variations within that range. Accuracy has been determined to within ±½ per cent in the range of 105 to 125 v and ±1 per cent over the entire expanded range. Although available in only one rating, 0-90 to 130 v, it can be supplied with



FEBRUARY, 1949

POWER GENERATION

53 W. Jackson Blvd.
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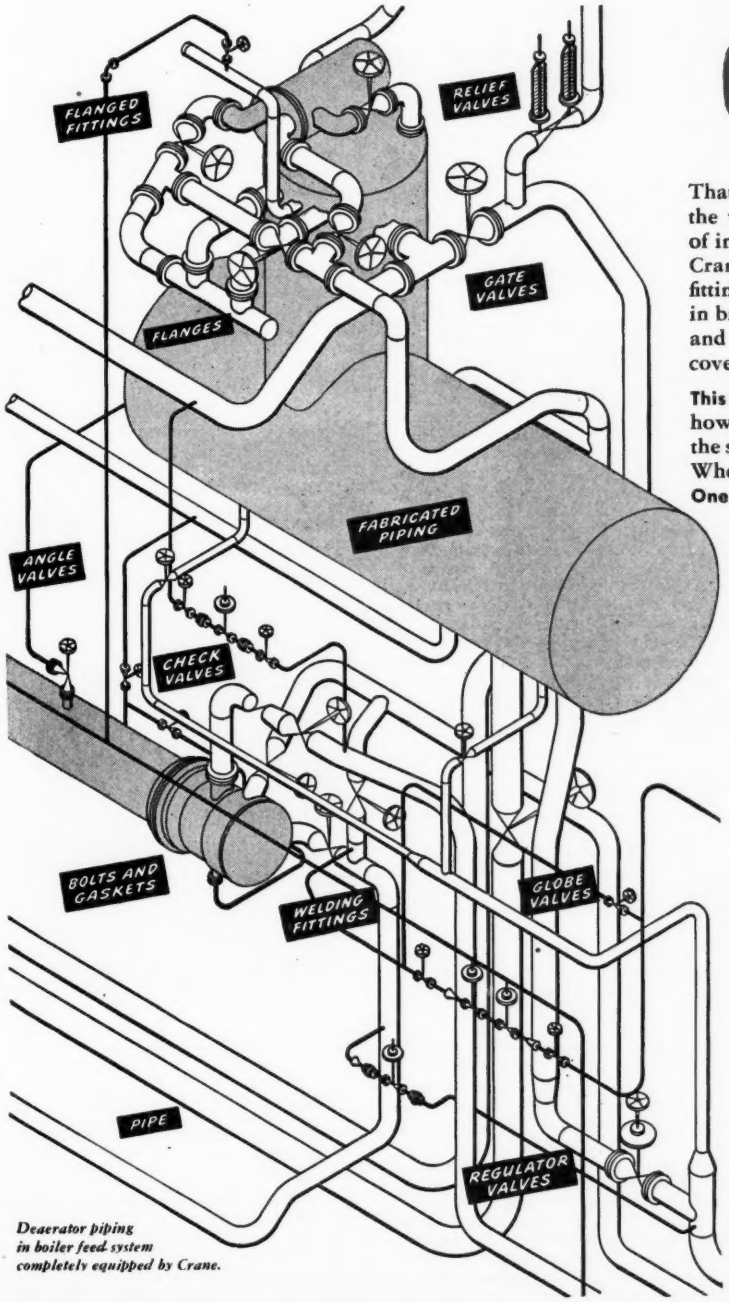

Deaerator piping in boiler feed system completely equipped by Crane.

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That's the kind of service you get from Crane, the world's leading manufacturer and supplier of industrial piping equipment. "Everything" at Crane includes an unequalled selection of valves, fittings, fabricated piping, pipe and accessories—in brass, iron, steel and alloys. One catalog . . . and one order to your nearest Crane Branch cover whatever is needed for the job.

This Deaerator Piping, for example, illustrates how completely Crane supplies everything for the system, regardless of the fluids to be handled. When you standardize on Crane, you depend on **One Source of Supply** broad enough to simplify every piping procedure. You get better installations . . . avoid needless delays . . . by placing **Undivided Responsibility** on Crane for materials. And for **Highest Quality** in every piping item, specify Crane Quality—unsurpassed for more than 90 years.

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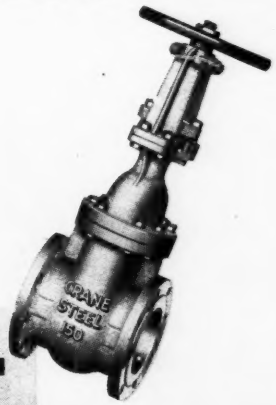
FOR TOUGH STEAM SERVICES *up to 750 deg. F., and for water, oil, air, gas and other non-lubricating liquids up to 500 deg. F., Crane recommends No. 47XR 150-pound Cast Steel Wedge Gate Valves. Designed for tight seating with long-lasting Exelloy to Nickel Alloy. Screwed, flanged or welding ends. Sizes: 2 in. and larger. See your Crane Catalog, p. 304.*



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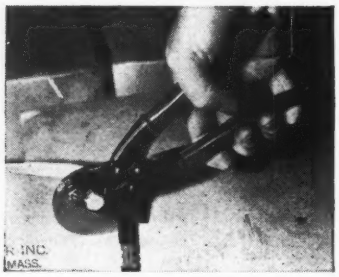
FOR EVERY PIPING SYSTEM

scales applicable to potential transformers for voltages higher than rated.

The new meter is housed in a dustproof, liquid-resistant case whose overall dimensions are 4¼x4¼x6⅜ in. It retains many of the features found in present G-E switchboard instruments: spring-mounted jewel pivots, anti-parallax scale, high overload characteristics, non-glare glas, shielding from stray fields, and stable performance under conditions of varying ambient temperatures.

The normal scale has a white background with black markings, but a black scale with white markings also can be furnished. General Electric Co.

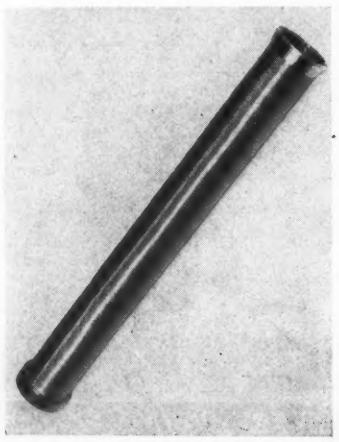
E Cutters. Here are triplets—born at the same time and built on the same lines. The family name is Hand-KliP. One is a shear cutter—cuts steel strapping, wire stay and box wire. Another is a wire cutter for cutting soft wires, rods, and ¼ in. bolts and the third one is an angle cutter for close



cutting of cotter pins, rods, bolts, etc. All three tools have the same power joint principle, the same pressed steel handles covered with a red plastic, unaffected by weather or water. These three tools are new in design from tip to tip, powerful, light and compact. H. K. Porter, Inc.

F For Filters. A new wire mesh membrane which can be used in any standard Titeflex filter has been developed.

The wire mesh membrane is a cylinder constructed of Type 316 stainless steel Dutch weave wire cloth and supported on the inside by a ⅛ in. thick perforated cylinder with a ring on each end to act as a bearing surface. Mesh of the standard membrane is 20 by 250, but membranes can be furnished in any mesh required. All joints of the membrane are welded.



The new wire mesh membranes can be used with either Filterbestos or diatomaceous earth as filtering mediums, and they are interchangeable with the porous stone membranes in Titeflex filters. They succesfully withstand high pressures and high temperatures. Because the wire mesh membrane can be used to filter any solution which does not attack Type 316 stainless steel, its range of applications are practically unlimited. It can be used without a filtering medium when solutions have fairly large suspended particles and only a fine straining operation is required.

Due to the very thin wall of the cylinder there is no danger of plugging and the wire mesh construction eliminates the possibility of breakage. Either the wire mesh membrane or the porous stone membrane can be supplied as standard on Titeflex filters, according to which is specified by the purchaser. Titeflex, Inc.

G Self-Lubricating Rings. Prior to the application of Morganite self-lubricating piston rings, the introduction of liquid cylinder lubricants into the air or gas stream seriously affected, and often prohibited, the use of compressors, according to this manufacturer. Food contamination in processing, danger of explosion and inaccurate instrument readings were said to be just a few of the serious drawbacks.

Various remedies including extractors and other auxiliary equipment were tried in an effort to remove the contaminating cylinder lubricant from the pressure stream. In no case were the results obtained entirely satisfactory. Where auxiliary equipment was used, maintenance costs were high.

Morganite Pressure Rings are said to offer a practical, complete and permanent solution. Because they require no lubrication, the cylinder remains completely free of lubricating agents and the pressurized stream pure.

In addition to self-lubricating qualities, Morganite rings are chemically inert, impart no taste, color or odor. The rings are mechanically strong and may be repositioned to compensate for wear before renewal is required. Carbon Specialties Department, Morganite, Inc.

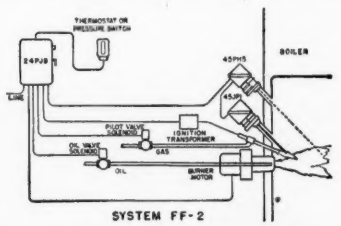
H Flame Failure Safeguard. To give complete protection against the hazard of explosion caused by flame failure in industrial oil burner installations, a system for supervising both the pilot gas flame and the main oil flame of fully automatic oil burners.

The equipment consists of Electronic Flame Rod Type 45JP1, Photoelectric Scanner Type 45PH5, and Programming Control Type 24PJ8.

The Flame Rod "feels" the gas pilot flame. If the pilot flame has not come on or is unsuitable for proper ignition, the flame rod signals this condition to the programming control and the burner shuts down before the main oil valve has even opened. With proper ignition, the main oil valve opens and the oil flame is then monitored by Scanner Type 45PH5.

The photoelectric scanner is exceedingly compact in design and readily installed. Since the scaner contains both the phototube and amplifier tube, no special shielded cable is required between the scanner and programming control. The photoelectric system is designed to withstand conditions of relatively high ambient temperature and is impervious to ambient humidity. It rep-

FULL-AUTOMATIC FLAME CONTROL, GAS PILOT AND OIL BURNER

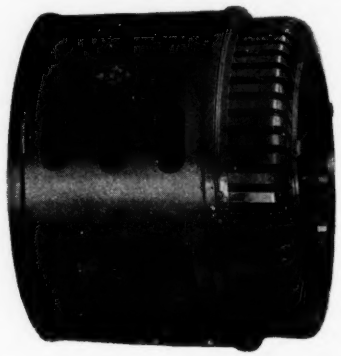


SYSTEM FF-2

resents the last word in electronic design and embodies safe failure features hitherto unavailable.

The programming control is designed to provide accurate setting of both oil valve delay and post ignition periods in seconds upon installation. Timing is accomplished through a synchronous motor. Relay contacts are of heavy duty type capable of handling directly a pump motor of 1 hp rating. The relay contacts are in an accessible location. Combustion Control Corp.

J Induction Motors. A new line of extra-low starting kva squirrel cage induction motors is announced. Called Design X, new line is available in flange-mounted type and coupled two-bearing type for direct coupling to 514, 600 and 720 rpm air compressors. Line permits full-voltage starting (across-the-line) with a starting kva of only 425 per cent as compared with 550 per cent starting kva of NEMA Design B motor. Full voltage starting is bet-



ter from the standpoint of power supply and requires simpler, lower cost control equipment.

This line added to company's line of extra low-starting kva synchronous motors is available in seven hp ratings in various cycle speeds. Electric Machinery Mfg. Co.

K Rotary Concrete Drill. A new and improved rotary concrete drill with exclusive design features that make possible a substantial cost-per-hole saving has been announced. Because of its unique core drill design and a side exhaust slot which permits core particles to escape, the drill penetrates concrete at the rate of two inches or more per minute in diameters of from ¼ in. to 2 in. Specially-treated sintered carbide cutters, located around the perimeter of the core where they operate at the most efficient speed, exert a quiet, pulverizing action which drills holes faster and leaves them straighter and cleaner.

By reducing labor time per hole to a

SMALL STEAM LEAKS *add up!*

Showing cost of various sized steam leaks at 100 pound pressure. (Assuming steam costs 50 cents per 1000 lbs.)

Size of Orifice	Lb. Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/2"	835,000	$417.50	$5,010.00
3/8"	470,000	235.00	2,820.00
1/4"	210,000	105.00	1,260.00
1/8"	52,500	26.25	315.00
1/16"	13,200	6.60	79.20
1/32"	3,400	1.70	20.40

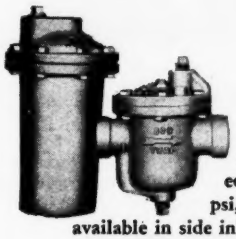
(For steam at 50 pounds pressure, the waste is about 75% of the above figures; at 20 pounds, it is about 50%; and at 5 pounds, the loss is about 25%.)

TYPICAL FUEL SAVINGS SECURED WITH ARMSTRONG TRAPS

20% FUEL SAVINGS after trapping all heating coils, individually. — Norton Greenhouses, St. Paul, Minn.

33-1/3% REDUCTION IN ANNUAL COAL BILL after installing Armstrong traps on cooking vats. — Ralph L. Smith Lumber Co., North Kansas City, Mo.

3,728 GALLONS OF FUEL OIL SAVED in one year after replacing old traps with Armstrongs on kettles, low pressure heating system and cream beaters. — Mary Lincoln Candies, Buffalo, N. Y.



STEAM SAVERS:

For trapping heating systems and process equipment from 1 to 250 psi, Armstrong Traps are available in side inlet—side outlet or bottom inlet—top outlet body styles. These compact, dependable traps provide more actual hot condensate capacity per dollar of trap investment than any other traps on the market. For selection data, capacities and prices SEND FOR the 36-page ARMSTRONG STEAM TRAP BOOK.

CHECK YOUR STEAM TRAPS *now!*

The chart above shows that a "little" steam leak can cost a lot—and a hundred or a thousand little leaks cost a lot more! No plant can afford the luxury of leaky steam traps. It costs far more to keep them than it does to replace them with modern Armstrong Inverted Bucket Steam Traps. Armstrong Traps won't leak steam because:

1. The valve and seat are ground and lapped to a precision, steam-tight fit.
2. The valve is water-sealed at all times.
3. Both the valve and seat are made of chrome steel, heat treated for long life and corrosion and erosion resistance.

With today's high fuel and operating costs Armstrong traps are priced lower in proportion to the savings they can effect than at any time in their history. Let your nearby Armstrong Representative help you select the traps you need or write direct to the factory.

ARMSTRONG MACHINE WORKS
810 MAPLE ST., THREE RIVERS, MICH.

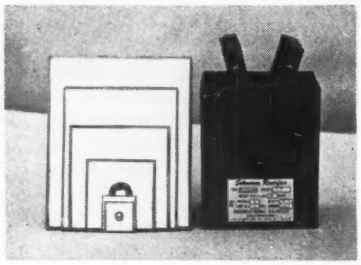
ARMSTRONG *Inverted Bucket* STEAM TRAPS

Factory Representatives in 48 Key Cities... Traps Stocked at 147 Points

fraction of that consumed by other methods, the drill effects an important saving in electrical work, plumbing, heating, air conditioning, sign hanging and many kinds of maintenance and installation work. The drill bit is designed for use with ordinary electric drill motors.

Glass, steel and rock, when imbedded in conrcete, are easily drilled with tool. The cutters can be resharpened on any ordinary grinder used for tungsten carbide. Tilden Tool Mfg. Co.

L Selenium Rectifiers Announced. A complete new line of selenium rectifiers covering the range from 2 v and 150 ma to 5000 v and 10,000 amp has been announced. The individual plate sizes range from 1¼ in. by 1¼ in. to 6¼ in. by 7¼ in, the latter size being the largest plate commercially available in the U. S. The plates are assembled in a unique interlocking arrangement between the plate and insulating sleeve so as to prevent possible plate rotation or lug misalignment.



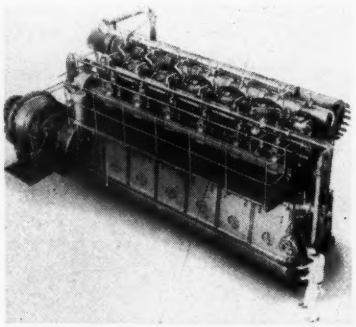
The individual selenium plates are capable of withstanding 24 v rms maximum in the reverse direction and can be overloaded up to 10 times rated load for periods of 7 seconds or less. Its characteristics are also extremely stable since the leakage is less than 1 ma/cm² at maximum reverse voltage. Efficiency varies from 65 per cent to 85 per cent depending upon the circuit employed and the change in voltage is less than 5 per cent after the first 10,000 hr of operation. International Rectifier Corp.

M Dual Fuel Diesel. A new 2-cycle, 21½" by 27½" dual-fuel diesel engine, with fast, easy changeover from gas to oil and oil to gas, and engine rating of 425 hp per cylinder in sizes of five to ten cylinders, has been introduced.

The dual-fuel engine is designed for operation on low-pressure gas with extremely low pilot fuel requirements, and is described as the first large, two-cycle, loop-scavenging engine to work satisfactorily on the low-pressure gas-injection principle. Excellent fuel economy, the manufacturer reports, is experienced with this engine throughout the complete load range, and combustion of fuel under all loads is complete and extremely quiet. Pilot fuel requirement rates as low as 8⅓ lb per hour per cylinder, according to the manufacturer, have been observed under test at 90 per cent load.

When arranged for dual-fuel operation, the engine rating of 425 hp per cylinder is at 240 rpm, whether running on gas or oil. This is a net rating at 100 per cent load, the company reported, and includes blower requirements. In performance, maintenance and control, no perceptible difference can be found between dual-fuel and straight diesel operation.

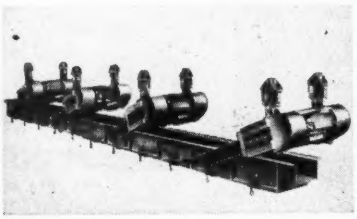
The new dual-fuel is based on the Hamilton 21½ by 27½ series 21-SA two-cycle diesel engine. This series,



because of its outstanding performance throughout the world, was selected as the basic engine for the new dual-fuel design, and for the application of thermodynamic improvements. These improvements have materially increased power output without increasing the pressures or temperatures in the cycle, and without increasing the rated speed of the engine. Lima-Hamilton Corp.

N Long Vibratory Conveyors. The availability of Long Vibratory Conveyors in various lengths and capacities—for suspension or base mounting—and powered by one or more Vibratory Motors mounted either above or below the trough, depending upon the available room, is announced.

This type of conveyor is particularly advantageous in the handling of extremely hot, abrasive materials—with sealed, tubular troughs to convey dusty, poisonous materials—or to convey pure



foods and pharmaceuticals free from contamination.

There are no belts, idlers or variable speed motors to maintain—the movement of the trough is confined entirely to the spring system of the vibratory motor—and a dial switch provides variable control of the rate of material flow—both a conveyor and a feeder in one unit.

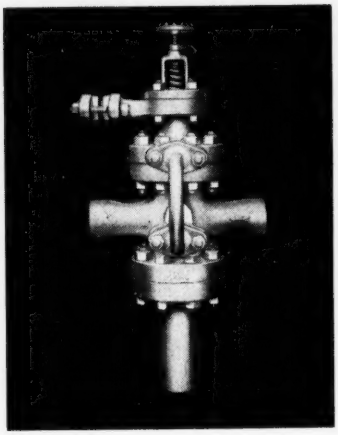
The particular unit illustrated is a heavy tonnage suspension type with an open flat pan trough, 20 ft long, and is one of four units making up a combined length of 80 ft, for supplying ore to retorts. The trough is equipped with gates located above each retort, for charging as desired. Syntron Co.

O Pressure Reducing Valve. A new type of high pressure reducing valve employing internal pilot piston operated construction has been announced.

The new valve, known as Class HS, is designed for steam, air or gas service. It handles inlet steam pressures from 300 to 1500 psi and air or gas inlet pressures from 300 to 3000 psi. Reduced pressure range is from 100 psi to 600 psi. Maximum inlet temperature is 1000F.

Construction of the new valve embraces a cast chrome moly steel body with integral stellited seating surface. Available in sizes 1 in., 1¼ in., 1½ in. and 2 in. with Series 90 or 150 flanges or welding ends.

No change of spring or diaphragm is needed from minimum to maximum reduced pressure setting. Valve is single seated, closing with the inlet pressure for positive dead-end shut off. Valve action is very fast with instant corrective reaction to any flow change,

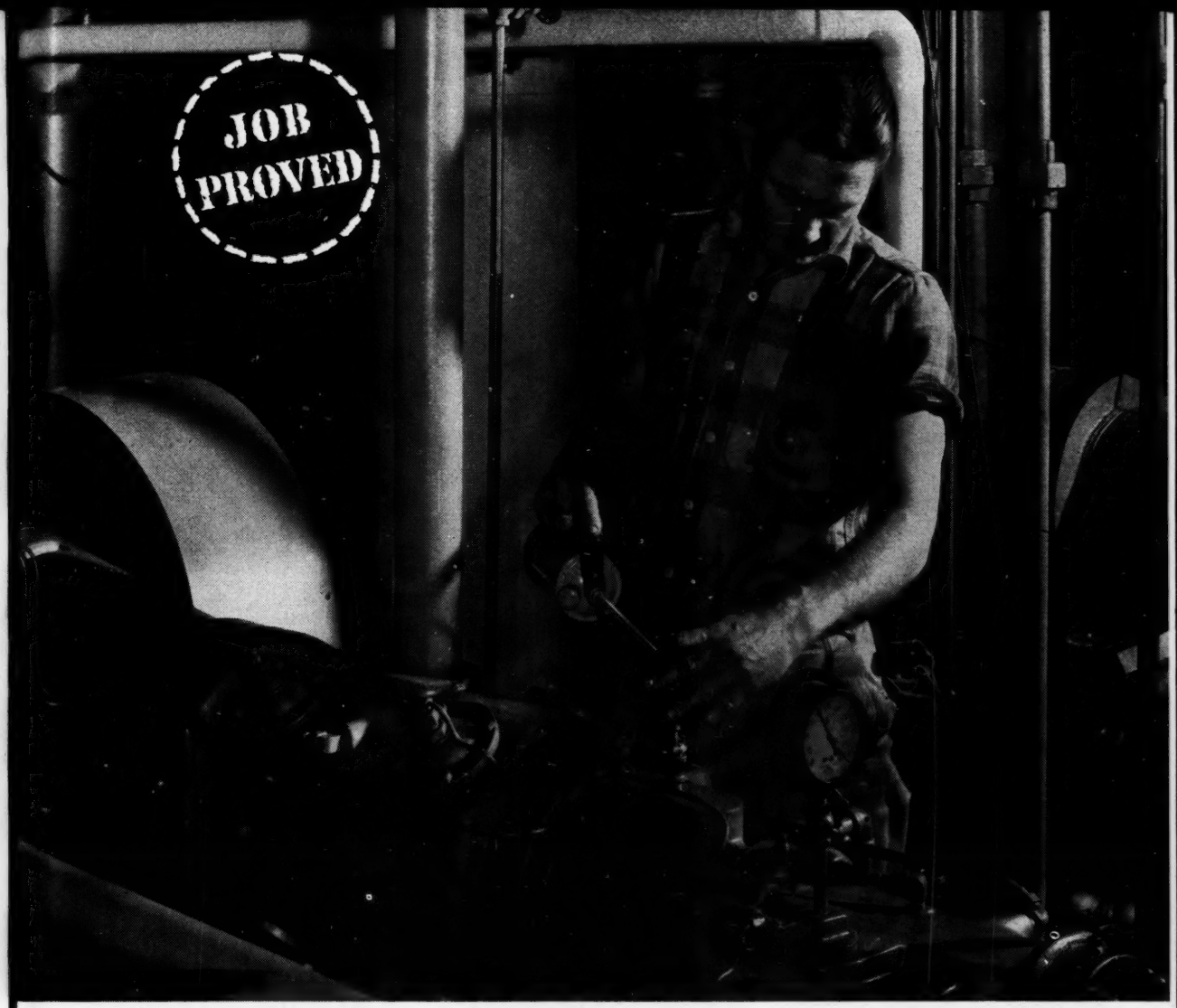


successfully used for high pressure steam soot blowers. Accuracy of regulation, maker states, is comparable to instrument control.

Interchangeability of replacement parts make a complete overhaul possible without removal of the main body from the pipe line. All renewable parts are wear and corrosion resistant. Main valve is hardened stainless steel with stellited seating surface. Controlling valve is solid stellite. Cylinder liner and piston are made of hardened stainless steel, highly ground finish. Valve has a monel diaphragm. Leslie Co.

P Lubricating Oil Testing Kit. To provide means for quick and simple measurements of the condition of lubricating oil this company has added a new equipment kit to its line of oil testing sets. This outfit is especially designed for use by mechanics and engine attendants in garages, power plants and railroads.

Aside from the speed with which tests can be made, the unusual feature of the



UNDER PRESSURE 11 YEARS...STILL GOING STRONG

A Sun Oil Helps Keep Compressor on the Job 16 Hours a Day—No Hard Carbon Forms

The "lungs" of a forced ventilation system in a large industrial plant are two-stage air compressors—pumping air through the system at 300 pounds per square inch.

One of these compressors, now over 11 years old, has been running 16 hours a day since its installation. From the start, a Sun lubricant has been used to lubricate crosshead and air cylinder. During the past five years there has been but one shutdown . . . and that occurred when a different brand of oil was used by mistake!

Operating on the Sun lubricant, the compressor is running as well today as ever. No hard carbon has formed. As a result of this record the plant has standardized on Sun lubricants for all its air compressors and vacuum pumps.

This performance is typical of the advantages gained from "Job Proved" Sun lubricants in thousands of industrial plants. Further information can be had from any Sun Office. For a copy of the booklet "Lubrication of Air Compressors and Pneumatic Tools" write Department PG-2.

SUN OIL COMPANY • *Philadelphia 3, Pa.*
In Canada: Sun Oil Company, Ltd.
Toronto and Montreal

SUN PETROLEUM PRODUCTS
"JOB PROVED" IN EVERY INDUSTRY

SUNOCO

new product is the accuracy of the results obtained by the relatively unskilled employee.

The equipment kit, which is portable, measures the four dangerous classes of contaminants: 1. Change in viscosity due to fuel dilution or other causes. 2. Amount of the asphaltic and other oil breakdown substances considered responsible for deposits. 3. Amount of dirt, metal particles, other solids and water. 4. Acidity, showing whether corrosion is possible.

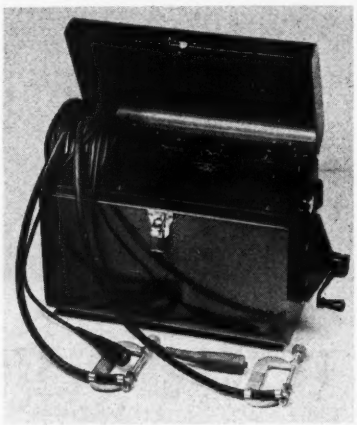
The oil from four engines can be analyzed for all four classes of contaminants in twenty-five minutes, so that changes and trends can be detected which give advance information that mechanical or operating troubles are in the making. The tests are also a necessary guide to making oil and filter changes according to their actual condition instead of according to time or mileage. Availability immediate. The Gerin Corp.

Q Radial Brush Holders. Newly developed special radial brush holders are now being furnished as standard parts on most of this company's large d-c motors for reversing operations. According to company engineers, the holders eliminate brush double-seating and chatter.

The brush spring in these special holders has a dual function. It not only maintains the brush pressure on the commutator but, in effect, produces a holder with zero circumferential brush clearance. While the spring prevents undesirable circumferential brush motion, it does not interfere with the radial motion necessary for smooth riding of the brush on the commutator. Allis-Chalmers Mfg. Co.

R Transformer Turn Ratio Test Set. A portable, direct-reading instrument for measuring turn ratio in power transformers. The set is designed for use on all types and sizes of power, distribution and auto transformers in common use, and reduces to a simple operation what heretofore has been a somewhat difficult task of measuring transformer ratio. Such measurements have frequently been a missing element during final inspection and at installation of transformers, and also are particularly helpful in analyzing transformer troubles and identifying tap connections. The set also gives an immediate indication of polarity.

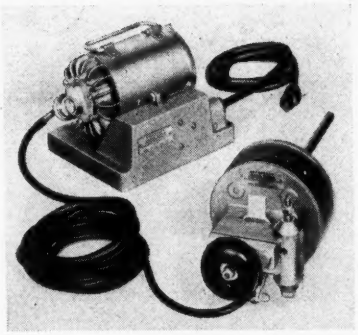
The Transformer Turn Ratio Test Set consists of a multi-ratio reference transformer which is excited—by means of a small hand generator—in parallel with the transformer under test. By means of four dial switches and a null balance indicator, the reference transformer is adjusted in ratio to equal that



of the transformer under test. The ratio is then read directly from the dial switch indexes. Ratios up to 130 can be measured with an accuracy to within one part in 1000. The set operates without burden, at low-voltage excitation and by null balance, and therefore gives a precise measurement of no-load voltage ratio. It is supplied complete with testing leads and weighs about 31 lb. It is intended for use both in the shop and in the field. James G. Biddle Co.

S Smoke Density Meter. A meter which is suitable for smoke density measurements of oil-burning equipment, as well as for sampling dust in the atmosphere and for other applications requiring knowledge of the concentration of particulate matter suspended in gas or air has been announced. This instrument makes a permanent record of an actual smoke sample on a paper test disc.

The meter consists of a sampling unit



and an electrically driven vacuum pump. Its operation is automatic. It is merely necessary to insert test disc, and flick the time control switch.

The meter can be adjusted to practically any desired smoke density range by varying the sampling interval between 30 and 90 seconds.

The smoke deposited on the test disc is an infallible measurement of the degree of its density, indicating even the slightest variation. The shadings of the "spots" on test discs provide an accurate means of grading the readings which assures precise, impersonal judgment of conditions being tested. Bacharach Industrial Instrument Co.

T Engine Descaling. A new series of De-Scaler units, designed for the prevention and removal of rust, corrosion and scale in the cooling systems of Diesel and large gasoline power engines, has been announced. The new EZ series includes De-Scalers for cooling systems having a water capacity of from 50 to 600 gal. Larger capacity cooling systems can employ De-Scalers in multiple units.

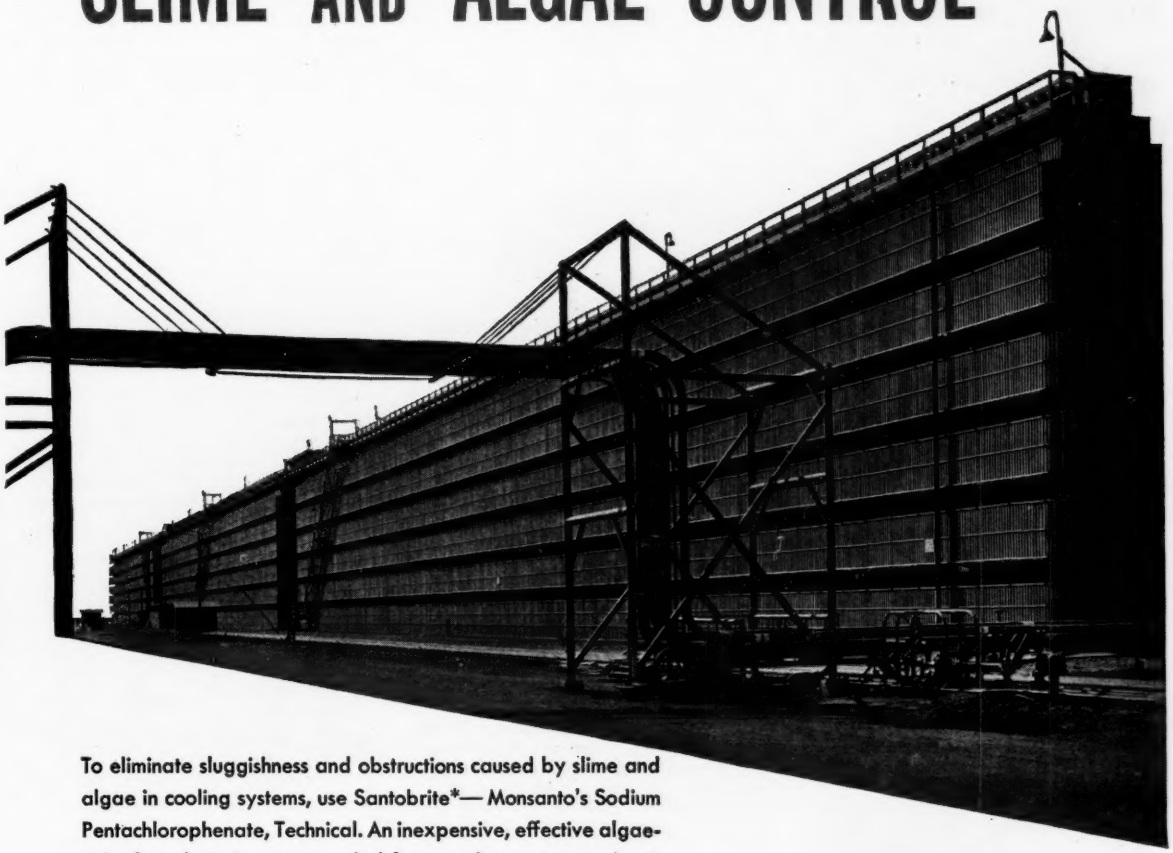
The series has been announced after more than two years of succesful tests on railroad, marine and stationary engines. Acting on the principle of a galvanic cell, Butler De-Scalers keep the cooling water free of scale-forming mineral content, remove existing rust and scale from the piping, radiator, heat exchangers and motor block and precipitate the mineral scalts, rust and scale to the bottom of the cooling system for easy drainage. The De-Scaler action employs no chemicals and replaces all chemical compounds for cooling sytem clean-outs. It can be used with anti-freeze.

Consisting of a silver-plated copper coil around a "Butler-metal" core, the De-Scalers have no moving parts. Replacement of the De-Scaler element once a year is all the attention required. In the EZ Models, these De-Scaler elements are housed in a polished brass casing fitted with removable plugs for easy element replacement. In use, they are installed on the water exhaust line, close to the motor. Butler Engineering Co.

U Engine Starter. A new, self-powered, friction-drive starter for Diesel or gas engines is announced. Known as the Lorain Friction Starter, the first models are in quantity production and available for short-time deliveries. While produced primarily for use on Lorain Diesel or Gas Engines, the manufacturer states that the starter can be used equally well on any horizontal or vertical type engine having an exposed flywheel.

The starter is powered by an air-

SANTOBRITE effective, low-cost SLIME AND ALGAE CONTROL



To eliminate sluggishness and obstructions caused by slime and algae in cooling systems, use Santobrite*— Monsanto's Sodium Pentachlorophenate, Technical. An inexpensive, effective algaecide, Santobrite is recommended for use wherever water is not used for drinking or bathing.

The Santobrite treatment requires no special equipment of any kind . . . Merely add to circulating water at any convenient location. Results are equally satisfactory whether used in large industrial installations or smaller systems.

To learn how Santobrite can help you maintain peak efficiency in cooling operations, send for a copy of Monsanto Technical Bulletin O-15. Address MONSANTO CHEMICAL COMPANY, Desk B, Organic Chemicals Division, 1765 South Second Street, St. Louis 4, Missouri.

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By removing all traces of residual oxygen, Santosite* (Monsanto's Sodium Sulfite, Technical) prevents oxygen corrosion in boiler tubes and other steam generating equipment. For complete information on this simple, economical control, send for a copy of Monsanto Technical Bulletin O-26. *Reg. U. S. Pat. Off.*

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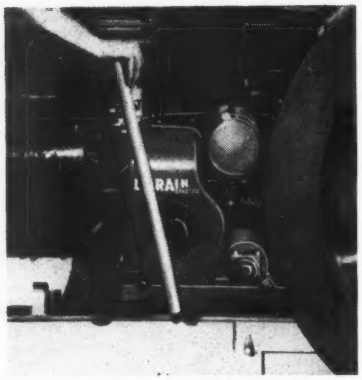


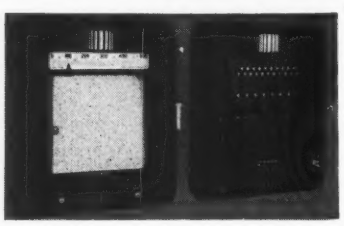
cooled, single-cylinder gasoline engine with 4 brake horsepower output. The gasoline engine drives a plastic composition friction pulley through a chain and sprocket reduction gearing system.

The starter is installed on the Diesel or gas engine so that the friction pulley contacts the flywheel rim when the operator manipulates the throw-in throw-out lever. This brings the Diesel or gas engine up to speed and the starter is disengaged.

The unit is shipped complete, ready for immediate installation. Shipping weight is 230 lb. Over-all dimensions are: length 18 in.; height 24 in.; width 21 in. White-Roth Machine Corp.

V Temperature Indicator, Recorder. Speedomax instrument automatically logs as many as 160 separate thermocouple temperatures in succession at a rate of 4 seconds per point. Because each point is checked at such frequent intervals, high or low temperatures which may develop can be spotted readily before serious trouble results.

In case of trouble, the operator can cut thermocouples out of the measuring sequence in banks of 20 at a time, until the instrument is concentrated on the



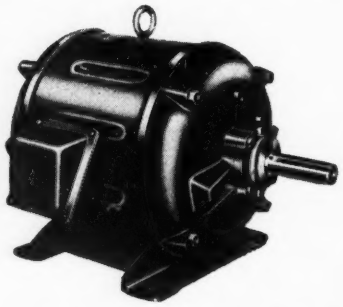
particular group of temperatures in which he is interested at the moment. Or, he can set the instrument to record any single thermocouple, or to record all points continuously.

In usual operation, the instrument simply indicates while numbered lights identify each couple. Should any temperature reach a preset limit, the Speedomax automatically starts its recording chart drive, begins to record all points as a series of numbered dots, and operates an alarm.

The equipment consists of two parts, a recorder and a switch assembly—both housed in separate cases. Leeds & Northrup Co.

W Drip-Proof Motors. Drip-proof design for its polyphase motors in the 254, 284, 324 and 326 frames has been adopted by this company. The motor frames of the new design are almost exactly like those of their prototypes which have proved themselves so well, differing from them only in the omission of all ventilating openings. They are formed of heavy rolled steel, shaped to accurately center the stator core and to provide passages between the frame and the core for ventilation. An auxiliary fan, larger in diameter than the armature of the motor, draws in air through the openings in the front endplate, forces it through these passages and out through the endplate openings on the drive end. Heat is effectively carried off from all parts of the motor.

Screens on the endplate openings give added protection by preventing rags, paper or similar articles from being

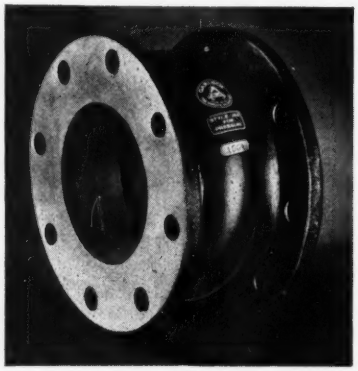


drawn into the motor, and they also prevent the entrance of rodents and other small animals.

Both sleeve-bearing and ball-bearing motors of the new design are completely drip-proof when mounted in the normal horizontal position, and, when the endplates have been correctly rotated, these motors are still drip-proof in the sidewall or ceiling horizontal positions because they have no openings in the frames. Wagner Electric Corp.

X Rubber Expansion Joints. These new rubber expansion joints are recommended by the manufacturer for installation in such places as piping in general, vacuum and water lines to and from condensers, pump suction and discharge lines, ventilating systems and others. They are made of a high grade rubber compound combined with piles of sturdy cotton duck and the whole reinforced with steel wire or rings. Flexibility is provided by a central arch in the body.

Made in three styles, for pressure, for vacuum and for both, these joints are suitable for handling hot or cold water, brine or exhaust steam at temperatures not to exceed 180 F. Advantages listed

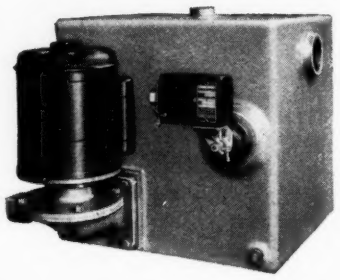


by the manufacturer include: long-lasting because the rubber does not crack under repeated flexing; does not take a permanent set; does not corrode or erode; light in weight and can be installed in a limited space; require no gaskets; do not induce electrolysis. Garlock Packing Co.

Y Condensation Pump. An entirely new, compact, low price condensation pump with several improved engineering features has just been developed. Known as the 4100 Series Condensation Pump, the new unit has a wide capacity range that solves the problem of stocking various sizes. It is conservatively rated to handle any capacity up to 6000 sq ft edr, against a discharge pressure up to 20 lb.

All parts such as the motor, pump, float switch, and drain plug are easily accessible from the front for quick inspection and fast servicing. Simply by removing four cap screws, the entire motor and impeller assembly may be lifted from the pump housing without disconnecting piping. Disassembly of the unit is accomplished without prying or hammering, only two hex keys and an open end wrench being required.

The two-piece construction of the bronze impeller has been designed specifically for this unit. Such design assures very smooth surfaces within the impeller passages to handle condensate



with the greatest efficiency in relation to pump size. The capacitor-start ¼ hp dual voltage motor is dynamically balanced for quiet operation. Vertical mounting above the pump, together with drip-proof enclosure, protects it from moisture. Condensate, is collected in a heavy 15-gal steel tank. A built-in strainer protects the pump from clogging. Levels are controlled with a non-corroding float set to a dependable single pole float switch. Sterling, Inc.

Z Soldering Flux. This new liquid aluminum soldering flux makes possible sweating on aluminum, stainless steel, monel, copper, brass, steel or any combinations of these metals.

This flux breaks the surface oxide on all types of aluminum so that a sweat job is possible. When used in combination with this company's All Metal Solder it is said to eliminate the electrolytic action between dissimilar metals so that a permanent bond, highly resistant to corrosion is obtained. Induction heaters as well as torch or iron can be used for heating mediums. This flux is $3.50 per pound. Farrelloy Company.

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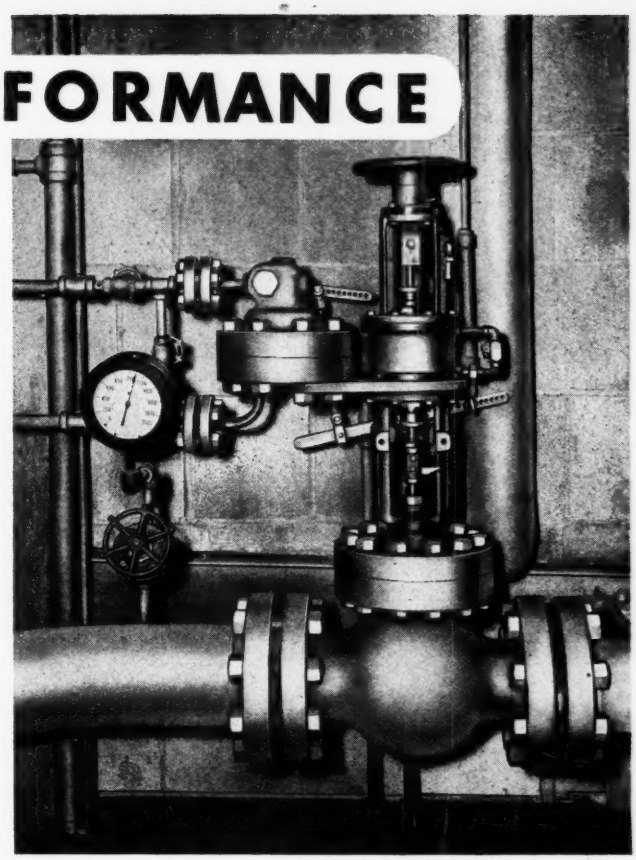

Installed in 1942 at the Bound Brook, New Jersey, plant of the Calco Chemical Division of American Cyanamid Company, this COPES Flowmatic Regulator gave good results from the start—even before combustion was under fully-automatic control—on the 900-psi Riley Type RP boiler rated at 200,000 pounds of steam per hour.

Three years later, Calco installed three more COPES Flowmatics to replace another type of feed water regulator on three older 480-psi boilers, each with maximum capacity of 100,000 pounds per hour. Only routine maintenance has been needed to keep all four COPES Flowmatics giving optimum performance since installation.

COPES Flowmatic Control gives you close control of boiler water level, regardless of range or speed of load fluctuation. Entirely indepdendent of instruments and other controls, it remains on full automatic during periods when they must be out of service for periodic maintenance. Simple and rugged, it handles emergency conditions as safely and dependably as it does normal operation.

These are the reasons why COPES Flowmatics have been ordered for more than 2800 boilers with pressures up to 1825 psi. Why you will find users in all of the 48 states and in 43 other countries. Why operation of your modern high-duty boilers will be safer and more efficient with two-element COPES Flowmatic Control—designed and built for your individual requirements, to fit any piping layout and operating preference.

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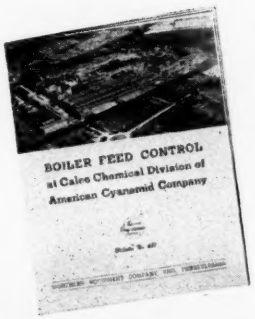

The story of COPES at Calco is told in Performance Report 481. Write for your copy—on your letterhead, please.

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When steam is turned on, Yarways open wide and discharge condensate continuously so that operating temperature is quickly reached. Then, under lighter condensate loads, Yarways discharge at short intervals to *keep* equipment at peak efficiency. Other Yarway features—small size, easy installation, straight through piping, low maintenance, only one moving part, low price.

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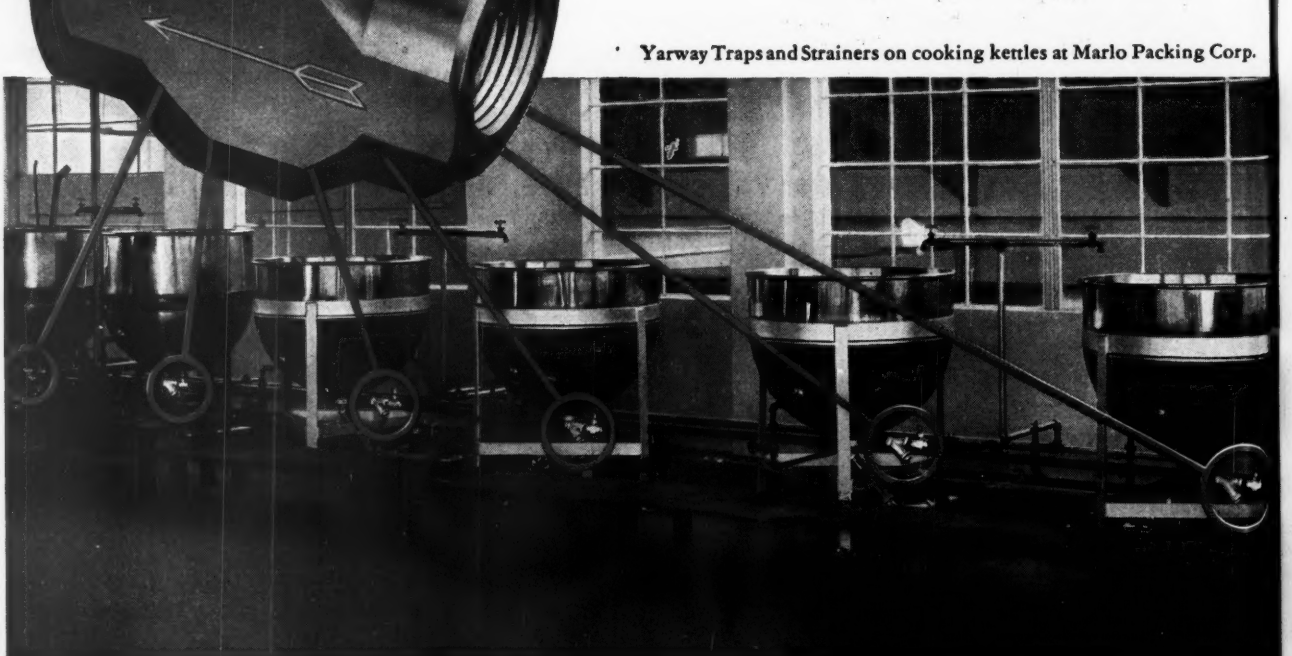


YARWAY IMPULSE STEAM TRAP

WHAT LEADERS SAY

American Industry Can Lead the World in Human Relations

By E. G. BAILEY

AMERICAN INDUSTRY and engineering can lead the world toward a solution of its problems of human relations, as they have led it through technical and economic progress toward a higher standard of living. At the same time industry must improve itself from within, and, to that end, it welcomes sound and constructive advice from all professions and classes of people.

Through science, engineering, and industry, man has conquered many of the forces of nature, enriched the world's supply of material goods and provided such services as power, transportation and communication. Man's standard of living has improved, but in the realm of human relations he has not made equivalent progress.

Philosophy, education, religion and civic organization have made deplorably slow progress in promoting happiness and peace for mankind, while invention in chemical and mechanical development—so useful in bettering our temporal needs—has been turned to fashion tools for destruction when suspicion, hatred, and selfishness have caused outbursts of war.

In modern warfare there is no longer a victor and a vanquished. Everyone loses—some possibly more than others—but a net loss is inevitable. There must be a course which can be followed to lead the world out of this savagery.

Engineers and industrialists have made a real start toward improving human relations. With the cooperative help of all others they can accomplish relatively as much in the field of good will among men as has been accomplished in supplying increased varieties and quantities of goods and services by utilizing the forces and resources of nature.

The answer to skeptics is evident in many companies today. Management has been building quietly but firmly and convincingly an excellent relationship between themselves, their employees, their customers, their stockholders and the community. Such companies exist in many different industries. They progressed to this status through real ability and leadership. What has already been done can be repeated extensively, until the great majority of all industry fits into this pattern, at which time the accomplishments will be unbelievably good.

A major change has taken place in management. It is now largely in the hands of competent men who have worked up within the industry and generally within the individual company. While the president or chief management officer is employed by and reports to a board of directors, nominally chosen by the stockholders, the management usually selects the nominees for directorships, and, in fact, runs the company. There is every reason why such self-propagating management should exist and continue as long as it is good and is satisfactory to the stockholders. This type of management will undoubtedly prove best in the long run in comparison with any previous form of manager-owner-employee relationship.

Industrial organizations, run on the basis of "Managerial Enterprise," seem to be the result of the evolution of good business and democracy, which have developed largely in the United States. This type of industrial organization will survive against all odds if we can realize the importance of properly training our young men to meet its opportunities and demands. Such training should start in the home and the church and continue through high school, college and industry.

As to the engineer's place in this industrial picture, the product is the life blood of a company. It must be kept healthy, and a source of pride and inspiration to every employee in the organization. The product or service must be kept up-to-date and fairly competitive. Methods of manufacture must be studied to maintain or improve quality at minimum costs. Both steps are largely engineering problems.

Despite the tendency in some quarters to regard the engineer as fitted only for association with the drafting board, slide rule and machine shop, the engineer's approach in his everyday work fits him admirably for realistic analysis of problems, regardless of their source. Possibly he has been too reticent. Engineers can use their knowledge of basic engineering principles in planning policies and solving problems of human and public relations.

The "perpetual fountain" called industry first provided the necessities of life, then the conveniences and luxuries and now people continue to want all they have and more, expecting their desires to be supplied in profusion with fewer and fewer man-hours of labor.

Hence there is an ever-increasing need for good judgment in selecting projects for research. There seems to be an urge not only to gamble heavily that we are going to cash in on many spectacular dreams, but

(Continued on page 108)

The above comments are abstracted from the presidential address by E. G. Bailey on Engineering Opportunities in Industry, delivered at the Annual Dinner and Honors Night of the 69th Annual Meeting of the ASME, New York, December 1, 1948.

All power engineers know E. G. Bailey, responsible for the Bailey boiler meter and many other measurement and control devices; the Bailey block and the Bailey stud-tube construction for water-cooled furnace walls; and many other devices now in wide use in power engineering. He has been responsible for many present-day developments in the field of combustion, holding more than 100 U. S. patents on various inventions. He is regarded both here and abroad as an authority on fuels, combustion and power developments. He is vice-president of The Babcock & Wilcox Co., and has just finished serving as president of ASME during 1948.

Active in all ASME affairs for many years, a keen observer of, and participant in, both business and civic affairs, and intimately concerned in the education and development of engineers, Mr. Bailey is in a most strategic position from which to comment on the engineering opportunities in American industry and especially on its problems of human relations.

O. H. Hutchings Station Now Serves Dayton-D

Initial 1250-psi, 950-F, 60,000-kw generating unit at new station in service since July, 1948. . . . Semi-outdoor steam generating units and auxiliaries a feature. . . . Ultimate capacity 360,000 kw. . . . Station heat rate now 10,800 Btu per kwhr net. . . . Details of plant site, circulating water facilities, coal and ash handling. . . . Dry-bottom furnace steam generating units, pulverized coal firing with tangential tilting burners; provision for carrying full output on gas as alternate fuel; capacity 550,000 lb per hr each. . . . Centralization of control. . . . Low manpower. . . . Performance data 6 months

By R. D. GILLESPIE

Manager, Power Production Division
The Dayton Power and Light Company

THE DAYTON POWER AND LIGHT CO., serving twenty-four counties in Southwestern Ohio, as of January 6, 1949 has had six months' operation of its 60,000-kw unit in the new O. H. Hutchings Station, described below. A summary of performance data is tabulated on page 57 and List of Equipment on page 58.

The new station, named in honor of the late O. H. Hutchings, a former vice president, general manager and director of the company, has a planned projected capacity of 360,000 kw. Mr. Hutchings, in his 57th year of service with the company, opened the throttle on the first unit as shown in Fig. 5.

O. H. Hutchings Station is located near Miamisburg, 10 miles south of Dayton, Ohio. Nineteen months were required from the time ground was broken until the first turbine-generator was on the line. The investment for the first unit, and for the principal facilities necessary to serve it and the other five projected units, represents a capital outlay of $15,000,000. It is expected that the second unit will be in operation in March 1949.

Plans were laid for the construction of this new station in the early years of World War II. Its operation today is very opportune in meeting the electrical demands of the prosperous Miami River Valley.

Growth of Dayton System

Before O. H. Hutchings Station, the sole source of generated power for the company was the Frank M. Tait Station.* In 1947, the send-out of Tait was 1,030,192,000 kwhr, coming from eight turbine generators with a total installed rated generating capacity of 210,000 kw. Three of these generators, each of 20,000 kw rated capacity, were installed in 1921, 1923 and 1924. Another, with an original rated capacity of 25,000 kw, was installed in 1928 but was rewound and otherwise altered in 1945 to give it a present rated capacity of 30,000 kw. Two high-pressure topping turbine generators, each of 30,000 kw rated capacity, were installed in 1937 and 1940. Two other low-pressure turbine-generators of the same capacity were installed in 1942 and 1944. Boilers at Tait consist of six low-pressure and four high-pressure units made by The Bobcock Wilcox Co.

Study of prospective system growth indicated the necessity for augmenting existing generating capacity. The economics of the situation and system load requirements dictated the construction of a new station as against further topping out or replacing of existing generating units in Tait Station with new and larger units.

Location of the new O. H. Hutchings Station is 14 river miles downstream from Tait Station on the west bank of the Great Miami River. The

* Originally named Millers Ford Station. For detailed data on operation of the station up to 1940, see Millers Ford—Three Years of High Temperature Operation, by R. D. Gillespie, *Power Plant Engineering*, June and July 1940.

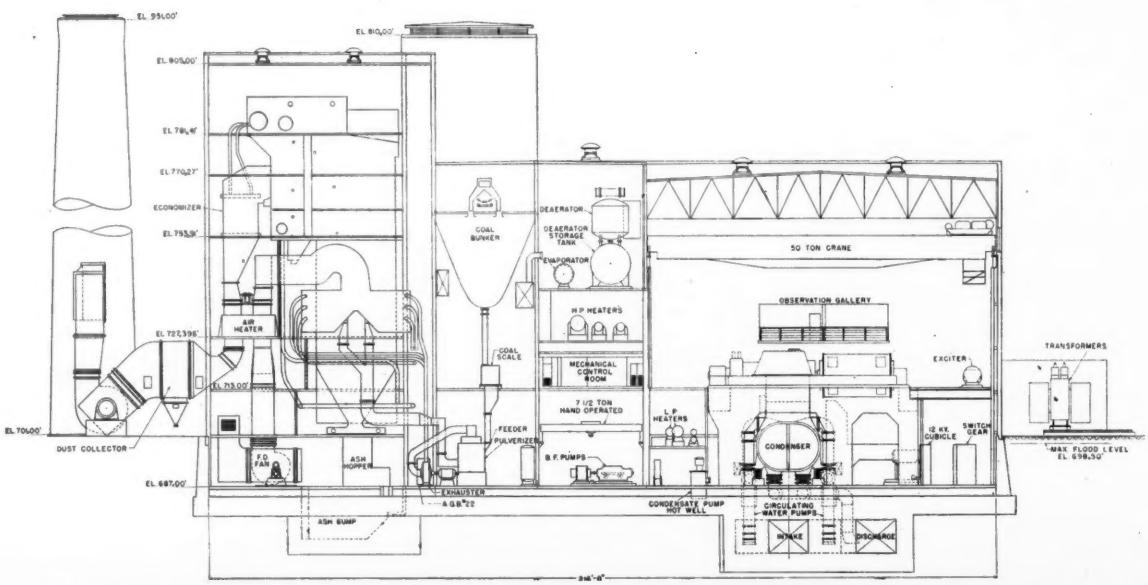


Fig. 1. General cross-section through initial installation, O. H. Hutchings Station, showing main units and principal auxiliaries

-Designed for Economy and Dependability

Fig. 2. Aerial view of O. H. Hutchings Station, showing semi-outdoor boilers and auxiliaries (2 boilers per stack), condenser circulating water intake and discharge arrangements, coal storage area in background and other features of initial installation

site is ideally suited to fulfill all requirements with respect to a supply of condensing water, nearness to main-line railroad facilities for receiving coal, convenient large ash disposal area, very favorable subterranean supply of water and favorable proximity to the load center of the area to be served.

In the old days, the Great Miami River had a reputation for going on flood rampages. The people of the Miami Valley corrected that by constructing dry reservoirs, as part of the Miami Conservancy District operations, to hold the river in check. Notwithstanding the effectiveness of this program, river conditions adjacent to the station site were considerably improved by widening and dredging the river channel and erecting substantial levees on both banks. The general level of the area around the station is 1.5 ft above extreme flood conditions and the station operating floor was placed 13 ft above grade.

Features of Station

The station is designed on the unit basis with one boiler and auxiliaries being installed for each turbine. No cross connections exist between units. The flue gases from two boilers discharge into a common stack.

As to the station itself, it is a 10-story equivalent structural steel-frame building faced with Indiana limestone and face brick. The interior facing of the walls is of glazed tile and the concrete floors have a terrazzo finish, which should minimize maintenance costs and contribute to good housekeeping. The control-room floors and office area floors are covered with terraflex, a resilient floor covering.

Other features in the station include fluorescent lighting, air conditioning, ventilation, recreational and sanitation facilities, first-aid, dining room, complete kitchen and conference rooms. All these items were included for the primary purpose of making the station a very attractive and pleasant place in which to work.

The station is also outstanding in that it is one of the first stations north of the Mason-Dixon Line to go into operation with boilers of the semi-outdoor type. Insulated aluminum panels are used to enclose the boilers at the burner and drum levels. At present, two boilers are completed. These discharge flue gas into a single stack 250 ft high; this stack has an independent inner stack made of red brick. This stack is shown in Figs. 1 and 2.

Main Turbine Generator and Auxiliaries

The turbine in service now, and the second delivered in January 1949, are of the tandem-compound, double-flow type, having 21 stages and operating at 3600 rpm, with throttle conditions of 1250 psig, 950 F and each turbine drives a 60,000-kw 0.85-pf, 3600-rpm, 12,500-v, hydrogen-cooled generator operating at 0.5 psig hydrogen pressure. An oil-operated, quick-closing type stop valve protects the speed of the solid rotor. Additional features that improve the reliability and safety include the following:

Protection against excessive starting speeds by a motor-operated synchronizing device on the main operating governor.

Automatic steam-seal regulator and unloading device.

Automatic low vacuum trip.

Emergency relief diaphragm on the exhaust casing in case the low-vacuum tripping device should fail.

An emergency overspeed governor of the oil tripped type that can be tested periodically without taking the turbine off the line.

Booster pump for turbine oil system.

Excitation by means of separate motor-generator of flywheel type.

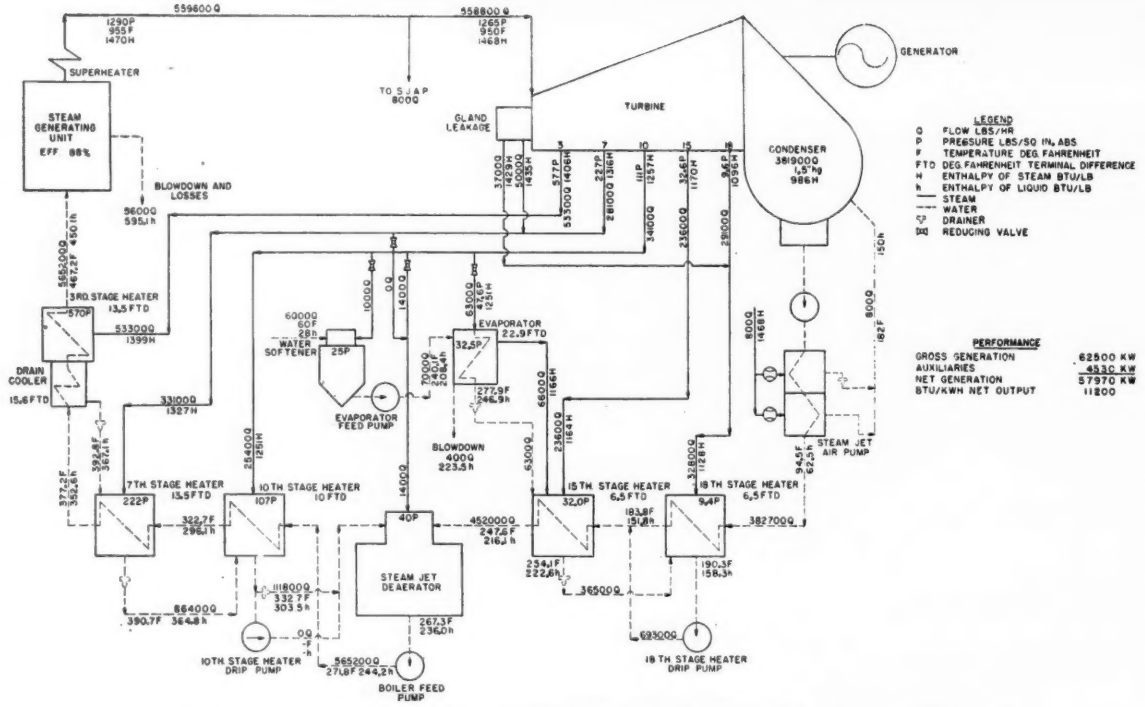


Fig. 3. Heat balance diagram for full load conditions on initial 60,000-kw unit at O. H. Hutchings Station

All parts containing high-pressure oil are housed to minimize fire hazards.

Condensing is accomplished with a two-pass horizontal condenser. Circulating water is pumped by two 21,600-gpm vertical circulating pumps operating during periods of high river temperature. Ordinarily only one pump will be required, except at full load or during the summer months. A two-stage steam-jet air ejector is provided for air removal. The condenser hotwell is built close to the floor and the condensate flows to either of two sumps, from which it is removed by vertical condensate pumps.

Extraction heaters of the U-tube type were selected for the reason they are deemed easier for maintenance than the floating-head type. To minimize internal boiler corrosion, a spray-type deaerating heater was provided.

An adequate supply of condensing water is assured from a pool of water made possible by an 8-ft dam across the Great Miami River adjacent to the station site, Fig. 6. A gate structure on the dam may be raised or lowered to permit recirculation or downstream discharge of condensing water. The distance down the river from the station water intake bay to the discharge gates on the dam is 1500 ft.

Steam is generated by two pulverized-fuel-fired boilers, each having a peak capacity of 550,000 lb of steam per hour at 950 F and 1250 psig. Superheat control is accomplished primarily by tilting the burners automatically; and, secondarily, by the use of by-pass dampers. Flue gas discharged from the air heaters, which are located out of doors, Fig. 1, go into the stack at 300 F with the boiler at normal full-load operation. Corten steel is used in the fabrication of the cold end element of the preheater in order to minimize corrosion. A fin-tube economizer is

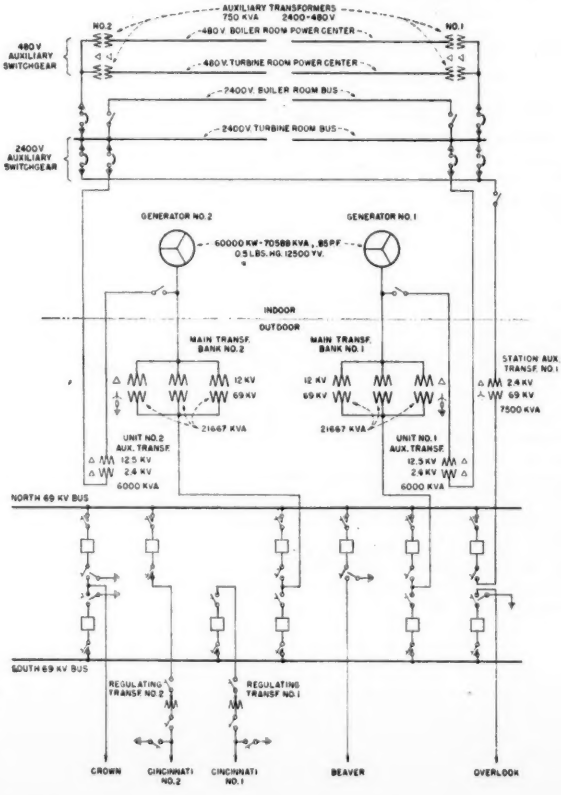


Fig. 4. One-line diagram of electrical connections, initial 60,000-kw installation, O. H. Hutchings Station

located between the boiler exit and the entrance to the regenerative type air heaters.

Dust collectors, and induced-draft fans are all located out of doors. Draft fans are fitted with hydraulic couplings. All breeching work is lined with gunite, exposed ducts and equipment are covered with weatherproof insulation. Uninsulated equipment located out of doors includes cold condensate tanks and the the sootblower air receivers.

Three coal pulverizers are installed with each boiler. There are 12 coal burners per boiler, fitted with tilting mechanism and with gas torches for lighting off. These torches are electrically ignited. Provisions have been made for burning natural gas, if desirable, by installing in each burner box six gas burners (or 24 per unit) capable of obtaining and maintaining full boiler capacity when gas of 1000 Btu per cu ft is burned.

The forced-draft fan, equipped with vane control, is located in the basement and receives air from the

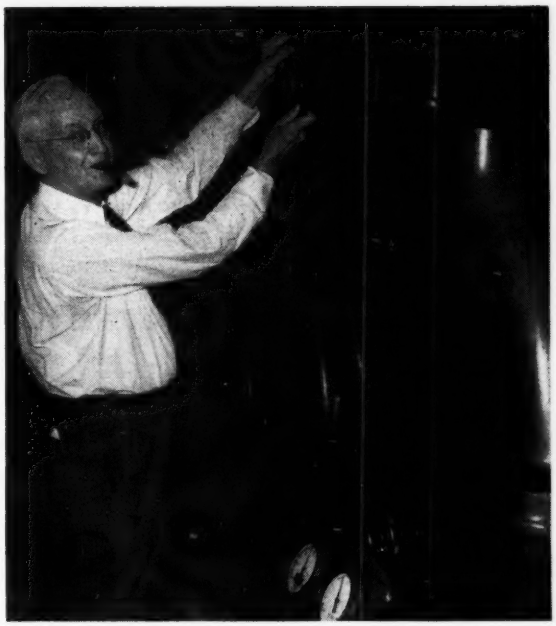


Fig. 5. View of the late O. H. Hutchings, vice president and general manager of the Dayton Power and Light Co. for whom the station was named, as he opened throttle to start up initial unit of new station

Table giving summary of performance, initial 60,000-kw unit, O. H. Hutchings Station, July 6, 1948 to December 31, 1948

July 6, 1948 to December 31, 1948	
Total hours in above period	4278 hrs
Hours unit available	4211 hrs
Per cent of time available	98.5%
Gross output for a 24-hour period	1,460,000 kwhr
Net load for same 24-hour period	1,379,000 kwhr
Largest output for any month to date (December 1948)	39,545,000 kwhr (net)
Forced outages, number	8
Total duration of forced outages	66 hrs, 57 min
Net heat rate (October, November, December)	10,800 Btu per kwhr (average)
Net coal rate (October, November, December)	0.82 lb per kwhr

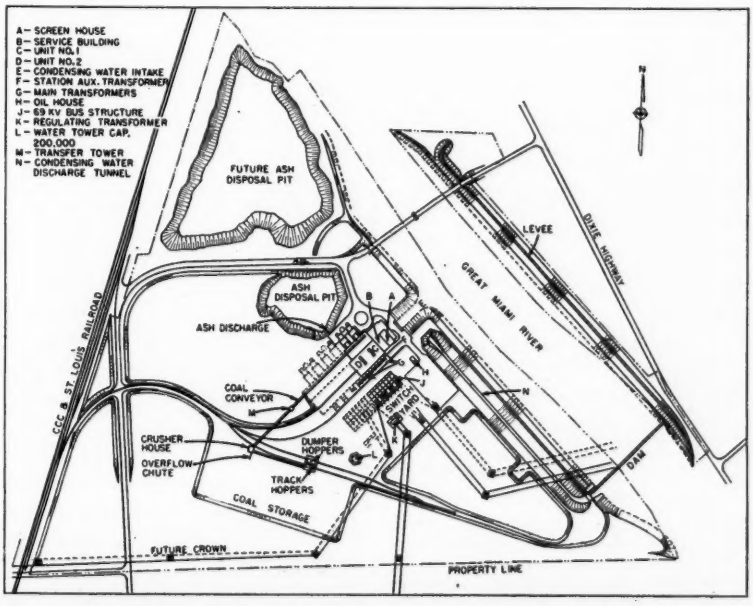


Fig. 6. General plan of site and property for new O. H. Hutchings Stations, showing facilities for circulating water, coal storage and ash disposal

building in the summer and from the outside in the winter. During the latter period, air heater corrosion is minimized by using tempering air from the air heater discharge.

Coal and Ash Handling

Coal is recevied in gondolas by rail and handled within the station yard by Diesel-electric locomotive. Cars are unloaded using a rotary car dumper of 100-ton capacity. The coal falls into two 200-ton hoppers and is shifted by apron feeders to a 700-ton-per-hr conveyor belt. These apron feeders also serve two 100-ton track or reclaiming hoppers. The conveyor belt terminates at a crusher house, where all or part of the coal may be discharged to storage. The coal to the station is screened on a vibrating screen and may be sent direct to the bunkers, size permitting, or crushed and then sent to the station. A 20-ton tractor that serves as a bulldozer, or as the prime mover for a 25 cubic yard carry-all, handles the coal for storage and reclaiming.

The conveyor belt from the crusher house to the transfer tower has a capacity of 350 tons per hour. At the transfer tower, the coal passes over a magnetic pulley and discharges past an automatic sampler to the horizontal conveyor. The housed conveyor system has a roof and floor made of concrete and the walls are of transite with no windows. A walk is provided on only one side of the conveyor, from which all lubrication is done.

Within the station, the coal is discharged by an automatic tripper into a sealed parabolic bunker of suspended steel construction, Fig. 1. The

(Continued on page 114)

(List of Equipment on page 58)

Principal Equipment - O. H. Hutchings Station

The Dayton Power and Light Company, Dayton, Ohio

Consulting Engineers ..... **Ebasco Services, Inc.**
Construction Supervision ..... **The Dayton Power and Light Co.**

STEAM GENERATING EQUIPMENT

Steam Generating Unit: — 2-Combustion Engineering Co., 3-drum type, 500,000 lb per hr continuous, 550,000 lb per hr for 12 hr; Operating pressure—1300 psig at S.O.; Design pressure—1500 psig. Heating Surface: Boiler—6600 sq ft. Furnace walls—9,510 sq ft. Furnace Data: Width—24' 2⅜", Depth —21' 4", Volume—34,000 cu ft gross. Liberation—18,800 Btu per cu ft. Tubes: roof—Finned tubes; front, sides and rear—plain tubes.

Superheater:—The Superheater Co. Elesco, 2-stage interbank (split), pendant type; steam temperature at outlet—950 F; Range —220,000 to 550,000 lb per hr. Temperature Control: Primary—tilting burners; Secondary—by-pass damper; both automatically controlled. Heating surface—16,537 sq ft.

Burners:—Combustion Engineering Co., 12 Type TV Burners per boiler, corner mounted for tangential firing; Tilting ±30°; provision for burning gas.

Pulverizer Mills:—Combustion Engineering Co.; Raymond bowl mills, 3 per boiler, 9 ton each.

Coal Scales:—Stock Engineering Co., 18 ton per hr, 400-lb hopper.

Air Preheaters:—Air Preheater Corp. Ljungstrom regenerative type; 2 per boiler; heating surface—43,180 sq ft.

Forced-Draft Fan:—B. F. Sturtevant Division (Westinghouse). 1 per boiler; Horizontal, double inlet. Control—inlet vanes and outlet damper. Capacity—154,000 cfm at 80 F, 12.3 in. H_2O; Drive—a-c, 400-hp, 2300-v, constant-speed motor.

Induced-Draft Fan:—B. F. Sturtevant Division (Westinghouse), 1 per boiler; horizontal, double inlet. Control—hydraulic coupling and inlet damper; capacity—267,000 cfm, at 308 F, 19.86 in. H_2O; Drive—a-c, 1200-hp, 2300-v, constant-speed motor. American Blower Co. hydraulic coupling.

Stack:—Rust Engineering Co. Inner stack red brick 14' x 250' and outer stack of radial brick, same height. Air admitted at ground level to space between stacks. Double cap with air sweeping over cap of outer stack. Stack serves two boilers. Ash removed by Hydrovactor.

Soot Blowers:—Diamond Power Specialty Corp. Automatic, sequential, air-puff; 14 A2E units; 4 continuous-blow retractable units and 8 furnace-wall blowers; 300 psig.

Dust Collector:—Aerotec Corp. 1 per boiler designed for 90% dust removal at full boiler output.

Chimney:—Rust Engineering Co., 1 for 2 boilers; 250 ft high, red brick independent lining, cont., inside dia. 14 ft; outside shell buff brick, inside dia. 16 ft, chimney corbelled to 19 ft 2½ in. at top. Outside dig at base 24 ft 2 in. Two breeching conns each 15 ft 7½ in. by 6 ft 7½ in. Division wall to deflect gases upward.

TURBINE GENERATOR EQUIPMENT

Turbine Generator:—General Electric Co. Turbine 1 tandem-compound, 21-stage, 60,000-kw, 1250-psig, 950-F, 1.5 in. Hg abs, 5 extraction points; driving 3600-rpm, 70,588 kva, 12,500-v, 60-cycles, 3-phase, hydrogen-cooled generator (0.5 psi. hydrogen press.) Second unit under construction.

Exciter:—General Electric Co. 1200 rpm, 200 kw, 250 v, shunt wound. Drive—G.E. 300-hp, 2300-v motor.

Condenser:—Allis-Chalmers Mfg. Co., 45,000 sq ft, two-pass, horizontal, surface condenser. Water inlet at top, outlet at bottom; common water box; 8,188 admiralty tubes, ⅞" O.D., No. 18 BWG, 24'-0" effective length.

Air Ejector: — Allis-Chalmers Mfg. Co., steam-jet, two-stage, twin-element; surface inter-cooler and aftercooler; 350 psig steam press. A-C hogging jet.

CONDENSATE AND FEEDWATER SYSTEM

Condensate Pumps: — Allis-Chalmers Mfg. Co.; 2 vertical, 14" x 8" two stage, single suction, 875 gpm, 250 ft total head, 1170 rpm. Drive—a-c, 100-hp, 440-v motor.

Condenser Circulating Water Pumps:—Allis-Chalmers Mfg. Co.; 2 vertical, 42" x 30", 21,600 gpm, 27.5 ft tdh, 587 rpm. Drive: a-c, 250-hp, 2300-v motor.

Boiler Feed Pumps:—Allis-Chalmers Mfg. Co.; one (with 1 spare for 2 units) 6" x 5", 7-stage, doubleton, centrifugal pump; 1190 gpm; 4250 ft tdh; 3580 rpm; automatic by-pass controlled by Bailey flow meter. Drive —a-c, 2,000-hp, 2300-v, constant-speed motor.

Closed Feedwater Heaters:—Griscom Russell Co. U-tube, horizontal

	Stage	Tubes Sq. ft.	Gage	
1	3rd	2807	15	70-30 cupro-nickel
1	7th	1470	15	70-30 cupro-nickel
1	10th	1470	15	70-30 cupro-nickel
1	15th	1647	18	arsenical copper
1	18th	2130	18	arsenical copper

Drain controls—Fisher Governor Co.

Heater Drain Pumps:—Low Pressure Heaters: One (1) 2-stage 1800 rpm, 200 gpm, 259 ft TDH, Drive—a-c, 25 hp, 440 v motor, Allis-Chalmers Mfg. Co.; High Pressure Heaters: One (1) 3550 rpm, 100 gpm, 88 ft tdh. Drive—a-c, 5 hp, 440 v. Worthington Pump & Machy Corp.

Deaerator:—Worthington Pump & Machinery Corp.; 640,000 lb per hr; double-shell, steam-jet type; max. op. press.—52 psig; storage tank—2,850 cu ft.

Evaporator:—Griscom-Russell Co. 1 horizontal Bentube; 18,000 lb per hr, 17 psig vapor. Tubes—No. 16 gage admiralty.

Water Softener:—Worthington Pump & Machinery Co. Hot process lime and soda, 6,250 gph, deaerating type, 10-min storage; design press.—10 psig; op. press.—5 psig. Filters—3 at 6'-6" diameter, 23.7 sq ft. Normal flow through filters—1.5 gal per sq ft per min.

MISCELLANEOUS PUMPS AND COMPRESSORS

Ash Sluice System: — Allen-Sherman-Hoff Co.; 2 A-S-H ash transfer pumps, 1100 gpm; 1 A-S-H bilge pump, 1100 gpm; 1 A-S-H Hydrovactor; 4" x 6", 150 psig supply. 2 Allis-Chalmers ash sluice pumps, 150 psig, 1500 gph. All pumps motor driven.

Boom Wash:—Allis-Chalmers Mfg. Co.; 1 8" x 6", 1500 gpm, 250 ft tdh, 1760 rpm. Drive—150-hp, 2300-v motor.

Screen Wash:—Allis-Chalmers Mfg. Co.; 2 —8" x 6", 1500 gpm, 250 ft tdh, 1760 rpm. Drive—150 hp, 2300-v motor.

Fire Pump:—Dayton-Dowd Co.; 1 - 1,000 gpm. 261 ft tdh, 1750 rpm. Drive—100-hp. 440-v motor.

Evaporator Feed: — Ingersoll-Rand Co.; 2-3450 rpm, 50 gpm, 150 ft tdh. Drive—a-c 5-hp, 440-v motor.

Chemical Feed:—Milton Roy Co.

Station Air Compressor: — Worthington Pump & Machinery Co.; Type YC-2, vertical, angle, double-acting, two-stage, water-cooled, with intercooler, aftercooler and 3-step variable capacity control; 100 psig, 541 cfm free air. Drive—100-hp, 440-v motor.

Soot Blowing Air Compressors:—Worthington Pump & Machinery Co.; 2 Type DC-2 horizontal, duplex, two-stage, water-cooled, with dual control, 500 psig, 552 cfm free air. Drive—200-hp, 2300-v motor.

Control Air Compressors:—Ingersoll-Rand Co.; 2 Class ER-1, horizontal, straight-line, single-stage, double-acting, water cooled; 100 psig, 80 cfm of free air. Drive—20-hp, 440-v motor.

Priming Pumps:—Nash Engineering Co.

Well Pumps:—Layne Ohio Co.; 3-1500 gpm. 278 ft. tdh. Drive—General Electric, 125-hp, 440-v motor.

Sump Pumps:—Yeomans Bros. Co.

INSTRUMENTS AND CONTROLS

Combustion and Superheat Control:—Leeds & Northrup Co.

Feedwater Control:—Bailey Meter Co.—3 element.

Level Controls:—Fisher Governor Co.

Flow Meters:—Bailey Meter Co.

Pressure Recorders:—Bailey Meter Co.

Temperature Recorders:—Leeds & Northrup Co.

Conductivity Recorders:—Leeds & Northrup Co.

Liquid Levels:—Recording, Bailey Meter Co.; Indicating, Yarway, Yarnall-Waring Co.

ELECTRICAL EQUIPMENT

Main Power Transformers:—3 — Westinghouse Electric Corp., 21,667-kva, 69,000/-12,000 v, oil-filled, self-cooled, single-phase transformers per unit.

Station Auxiliary Transformer:—1 — Westinghouse Electric Corp., 7500-kva, 69,000/-2400-v, oil-filled, self-cooled, 3-phase transformer for present station.

Unit Auxiliary Transformer:—1—Westinghouse Electric Corp., 6000-kva, 12,000/2400-v, oil-filled, self-cooled, 3-phase transformer per unit.

Auxiliary Power, 440 V:—2—Wagner Electric Corp., 750-kva, 2400/440-v, dry-type, 3-phase transformers per unit.

Lighting Transformers:—1 — Wagner Electric Co., 150-kva, 2400/208-v, dry-type, 3-phase transformer per unit. 3—General Electric Co., 25-kva, 460/230-v, single-phase, dry transformers connected as a 3-phase bank for turbine room lighting.

69,000-v Switchgear:—Westinghouse Electric Corp. "De-ion Grid" oil circuit breakers, outdoor type, 69,000 v., 1200 amp rating, pneumatic-operated.

2400-v Switchgear:—Westinghouse Electric Corp. Metal Clad Switchgear with "De-ion" air circuit breakers.

440-v Switchgear: — 2—I-T-E- Circuit Breaker Co., Multumite substations per unit.

Motor Contactor Starting Panels, 440 v:—Powerlite Switchboard Co.

Main Electrical Switchboard: — Westinghouse Electric Corp.

Storage Batteries:—The Electric Storage Battery Co.,; 2—60-cell, 660-amp-hr. Exide control batteries for general station control. 2—60 cell, 10 amp-hr Exide batteries for use with carrier relaying.

Transformers for A-C Control:—3—Wagner Electric Corp., 3-kva, 440/110-v single-phase transformers connected as a 3-phase bank.

Motors:—Allis-Chalmers Mfg. Co. except as noted. Motors of over 125 hp wound for 2400 v; 125 hp and below for 440 v. All motors line start; insulated with Class B insulation.

STATION VENTILATION

Main Building Air Filter:—Dollinger, viscose type oil filters; 221,800 cfm (total).

Air Conditioning Filters, Viscose Type:—Oil filters, American Air Filter Co., 35,000 cfm & 10,000 cfm.

Electrical Control Room Air Conditioning Filter: — Electrostatic type—American Air Filter Co., 6000 cfm.

Mechanical Control Room, Air Conditioning Filter:—Electrostatic type — American Air Filter Co., 4100 cfm.

Building Ventilation Fans:—Boiler Room and Auxiliary Bay, 2 fans, 150,000 cfm each; Buffalo Forge Co.

Coal Bunker Fan:—1—12,000 cfm; Buffalo Forge Co. with Rotoclone dust collector,

Service Building Ventilation Fans:—Fan 5 —6000 cfm; Fan 6—11,400 cfm; Fan 7—14,500 cfm; total 31,900 cfm; American Blower Co.

Air Conditioning Fans—Service Building:—Unit 1—5100 cfm; Unit 2—5500 cfm; Unit 3 —6500 cfm; total, 17,100 cfm; Frigidaire Corp.

Dehumidifier: — Kathabar—Lithium Chloride, 5,000 cfm. Surface Combustion Co.

OTHER EQUIPMENT

Car Dumper:—Link-Belt Co., 100-ton; 20 cars per hr.

Coal Crusher:—American Pulverizer Co.—350 tons per hr, 12 in. max. coal.

Coal-Handling System:—C. O. Bartlett & Snow Co.

Carryall:—Gar Wood Industries; 25 cu yd, Model 528.

Tractor:—Allis-Chalmers Mfg. Co., Model RD-19.

Elevators:—Otis Elevator Co.—Service Elevator, 5000 lb capacity; Passenger Elevator 2500 lb capacity.

Traveling Screens:—Chain Belt Co.—2 Rex Screens in series; 1st—⅜" mesh; 2nd—¼" mesh.

Chlorination:—Wallace and Tiernan Products, Inc.

Piping:—Pittsburgh Piping & Equipment Co.—All Electrically welded.

Valves:—Wm. Powell Co., over 1/3 of major valves motor-operated, with remote control from central control room.

Steam Generator:—For station heating system, 2 Ames Iron Works, Amesteam Generators; rated capacity each 80 blr-hp, 125 psi, gas fired.

In the first part of this article in the January issue, the author discussed the reasons for using chemical methods of cleaning boilers and the principles involved in such cleaning methods. Now, in this second installment, he describes the influence of various chemical cleaning methods on modern boiler design

Solvent Cleaning and Boiler Design-II

By E. R. KILSBY,
Assistant Manager, Service Department, Foster Wheeler Corporation

REASONS for the use of solvent cleaning methods as well as the principles involved were presented in the first part of this article. Now, we will consider the effect of solvent cleaning on boiler design.

Figure 8, for example, illustrates the twin furnace steam generators operated by a large utility company. In these units a radiant type superheater covers one wall surface and the products of combustion in this furnace pass from the bottom of the furnace upward over convection superheater surfaces. The other three walls of this furnace are faced with water tubes. The second furnace contains no superheating surface and water tubes cover the faces of all its walls.

By adjusting, or varying, the amount of fuel burned in each furnace, a substantially constant steam temperature is provided. In addition, and a primary factor in the design, is the effect of the cooling surface of the eight walls which per-

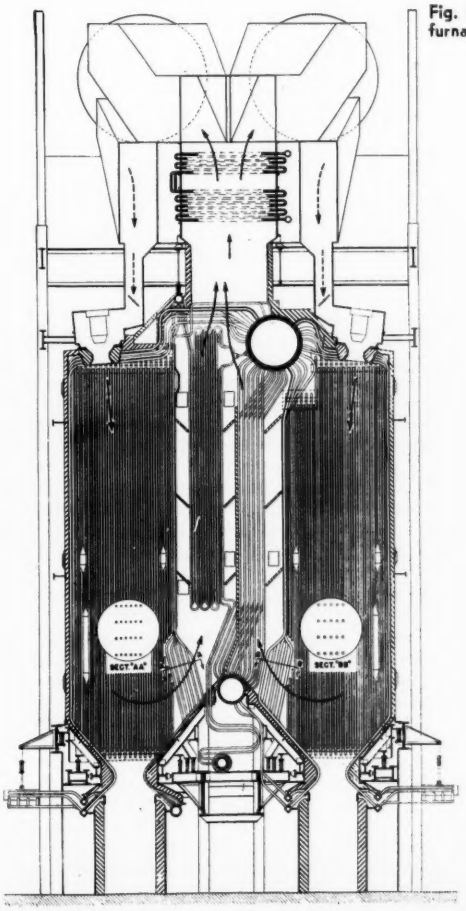


Fig. 8. (Left). Twin furnace steam generator

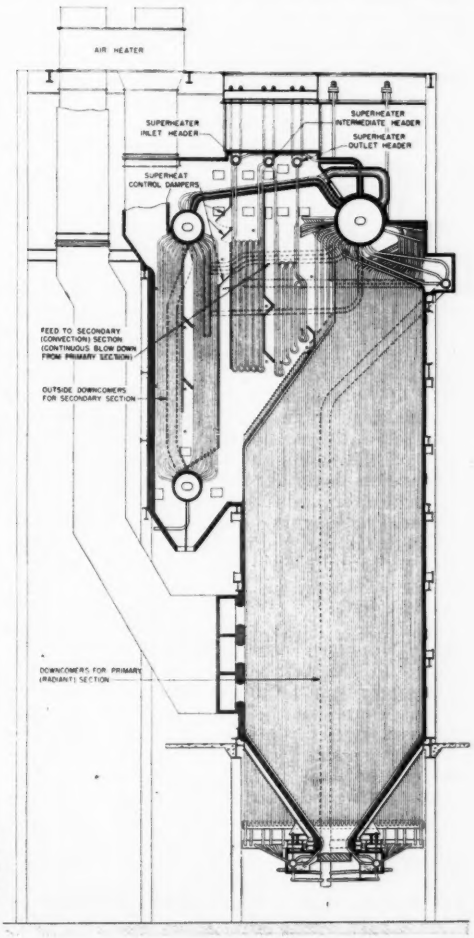

AIR HEATER
SUPERHEATER INLET HEADER
SUPERHEATER INTERMEDIATE HEADER
SUPERHEATER OUTLET HEADER
SUPERHEAT CONTROL DAMPERS
FEED TO SECONDARY (CONVECTION) SECTION (CONTINUOUS BLOW DOWN FROM PRIMARY SECTION)
OUTSIDE DOWNCOMERS FOR SECONDARY SECTION
DOWNCOMERS FOR PRIMARY (RADIANT) SECTION

Fig. 9. (Right). In this boiler, built for operation at 1350 psi there are two different concentrations of solids

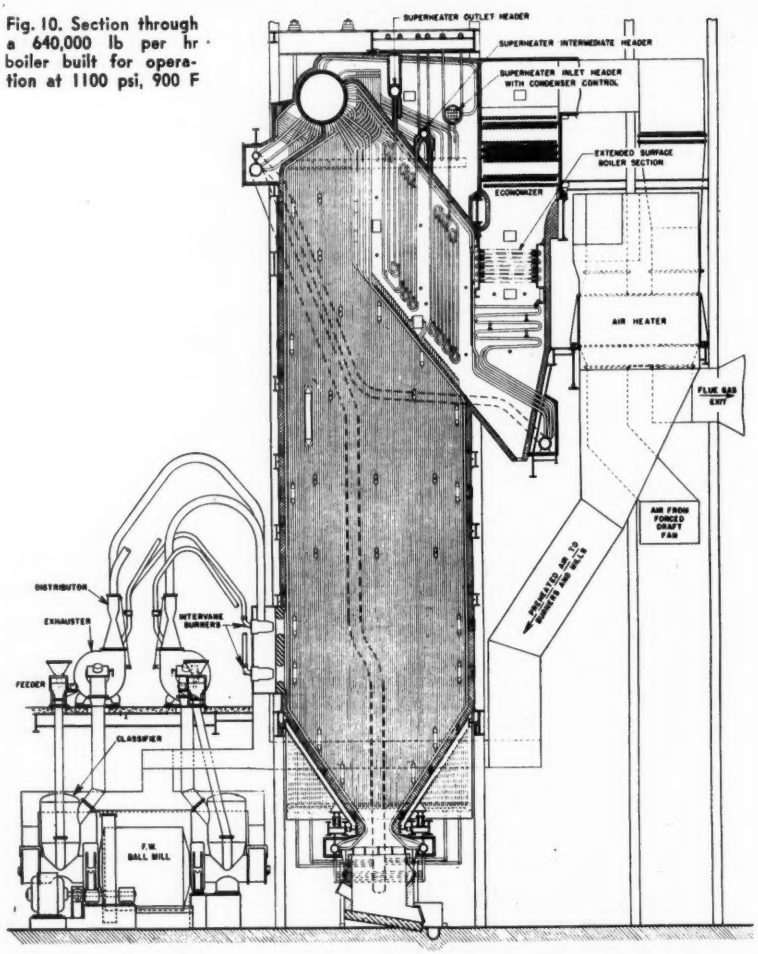
mit the burning of coals with low fusion point ash, without forced outages due to slag, and without such frequent use of slag blowers as in many plants using coal having higher fusion point ash. The conventional soot blowers serving convection surfaces in the gas passes are seldom used.

The internal cleaning of these units would present a serious problem for most mechanical tube cleaners. The steam drums contain considerable steam purification apparatus as the steam produced must contain less than 1 ppm of solids when delivering 400,000 lb of steam per hr at 1300 psi. The steam is superheated to 915 F.

Figure 9 illustrates a unit for initial operation at 400 psi, later to operate at 1350 psi, capacity to be 300,000 lb per hr with a final steam temperature of 900 F. Feedwater may be 100 per cent make-up. This design is unique in that the water in the boiler will have two different concentrations of solids. In the front, or primary, generating section water will contain solids up to 450 ppm and this water will, in the course of its circulation, pass over to the rear, or secondary, section in which solids will be allowed to increase to 1000 ppm. Steam is to contain not more than 1 ppm. "Treatment" of the only water available, to the degree necessary to avoid objectionable scale formations, and prevent moisture carryover in steam, for short periods, is too expensive. Reduction of solids content of water in those regions of the boiler where most heat is absorbed, reduces scaling possibilities. It might be possible to achieve the solids reduction by employing a high rate of blow down, but the heat lost by the excessive blow down rate, which the high solids content of this feedwater involves, would be extremely costly.

Figure 10 shows a boiler 114 ft high. Its capacity is 640,000 lb of steam per hr at 1100 psi and 900 F. Note the unusual horizontal runs and bends of tubing in the rear section below the economizer. This is part of the boiler heating surface and water flows through it under "natural circulation" head only. The design of tubes would pose a difficult study to anyone intending to clean them internally by mechanical means. Chill rings are used in welded joints of such long tubes, and this unit is an "all-welded" design. Tubes are welded into socket holes and the number of handhole openings is held to the absolute minimum. These will be for inspection purposes, but only a few are placed in each header. Projecting nipples, welded in place, afford additional access if needed during operation. These are designed so that their ends may be cut off by a torch, and rewelded after work through them has been completed. One such nipple will be provided for each group of several tube ends. The intent was,

Fig. 10. Section through a 640,000 lb per hr boiler built for operation at 1100 psi, 900 F



clearly, to clean this section chemically. Forced circulation boiler designs will, no doubt, become more acceptable as solvent cleaning progresses. One of the greatest advantages inherent in forced circulation designs is the ability to arrange tubular heating surface in almost any manner that lends itself to most effective heat absorption. That contemplates boilers of smaller dimensions and lower cost. Chemical cleaning may well be considered essential for boilers of the forced circulation type. The saving in weight and space will prove most attractive to marine engineers.

Solvent Used For External Deposits

At about the time solvent cleaning for the interior surfaces of superheaters first came into use, it was common practice to provide sprays of water for cleaning external surfaces of armored type economizers.

Soot blowing equipment was not as effective then as at present, nor was it ordinarily recognized that the steam used for blowing must be perfectly dry when it leaves the jets of the blower. Wet steam saturated the soot accumulations, which would then be more tenaciously retained upon the "extended surface." Actually, the effect was to bind the separate flakes of soot and ash more securely together. Dew point of the gases was given little attention and often was responsible for the deposits. Sulphur in the deposited particles combined with the water to form weak sulphuric acid which, in turn, partially dissolved other ash or soot constituents. When soot blowing was completed, the hot gases of combustion evaporated the moisture leaving a dense, "caked" coating. Such deposits were impervious to subsequent soot blowing, even with superheated steam. This was particularly true in plants burning low grade coals or those high in sulphur. Moreover, it was not then, and to a surprising degree is not realized even now, that the critical influence in the dew-point wetting of surfaces is temperature of metal rather than temperature of the gas. The gas temperature may be somewhat above dew-point corresponding to the sulphur percentage content, but the heat absorbing, surface metal temperature may be slightly below the gas dew-point. The metal then "sweats," picks up ash and soot particles until equilibrium temperature is reached. The condensate ("dew" or "sweat") becomes weak sulphuric

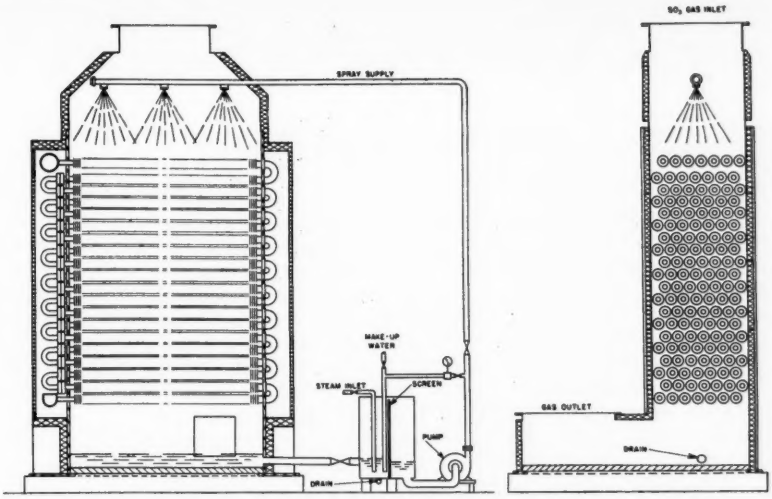


Fig. 11. Arrangement for cleaning the external surfaces of a waste heat boiler

acid. It was because this condition had been experienced with economizers for years, that bare steel tubes were not used. They corroded too rapidly, just as the early marine superheaters had done.

The same conditions apply to air heater fouling; the deposits are sulphates, primarily.

The washing procedure for economizers has been about as follows:

Removal of Hard Caked Deposits From Exterior of Extended Surface Economizers by Washing

The unit is shut down. The economizer gas outlet to stack may be opened to permit escape of vapors, but inlet should be closed, either by closing boiler damper or by closing all apertures for admission of air to boiler or furnace, so that no air flows through economizer.

If the installation does not include an ash hopper directly below the economizer, or if the water to be sprayed onto the economizer surface will run back or down gas ducts, a temporary trough should be installed directly below the bottom row of economizers elements to span the complete width and length of the economizer. It may be built of tongue and groove lumber and a large drain from this trough should be connected to the sewer.

Spray pipes, or nozzles, of adequate number, type and size to provide a soft spray of hot water evenly distributed over the width and length of the economizer should be arranged directly above the top row of the economizer elements. Water temperature ought to be between 150 and 160 F, and the quantity sufficient to result in continual, rapid dripping from the underside of all bottom row elements, over their entire length, after water has fully penetrated through the complete height of the economizer assembly.

A moderate flow of hot water through the element tubes is beneficial and should be provided when reasonably practicable. This water should not be hotter than 220 F entering the economizer; under no circumstances hot enough to cause evaporation of the external spray water.

Continue the spray for ten to twelve hours, unless inspection of center and bottom of economizer shows soot deposits to have fallen off earlier.

After spraying, as described, the deposits should be quite soft.

Next, use a high pressure, high velocity, hose or nozzle stream, washing from the top down, to carry off any deposits still remaining. In extreme cases, the stream may have to be applied to centrally located elements through inspection holes in the sides of the economizer casing.

When satisfactory cleanliness is attained, the nozzles and trough should be removed and a fire started of sufficient intensity to provide gases above 300 F leaving economizer. Continue this firing until all moisture and corrosive liquids, resulting from the washing, have been evaporated.

Put this drying procedure into effect without delay and prolong it sufficiently to completely dry all insulation as well as surfaces. Water flow through the elements is, of course, necessary when gases are sufficiently hot to damage a dry economizer.

Recognition of the causes of exterior fouling led to limitation of designs, and economizer applications only under conditions normally assuring that no metal would be at gas dew-point temperature.

In some instances the hard material found on external economizer surface does not result from dew-point factors. Quite the contrary. Secondary combustion in the last passes of a boiler sometimes softens ash particles in the gases so that they reach the economizer in a plastic state. Striking a surface considerably cooler than the boiler tubes, these particles solidify, one with another. The product is comparable to a plastic refractory material after subjection to high temperature. Such instances require an analysis of the accumulated material, before determination of a suitable solvent, to be used as described above for water washing. It has been found that water will often cause sufficient dissolution of the small amounts of sul-

(Continued on page 114)

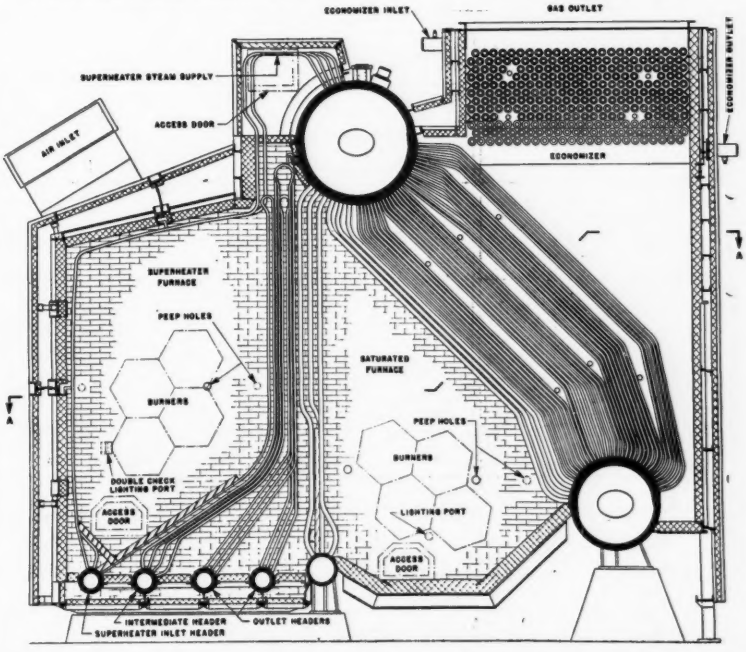


Fig. 12. Navy type marine steam generator

How Tankage and Operating Air Pressure Influence Pneumatic Control Systems

In a pneumatic control system, tankage and air pressure influence number of compressor startings, time the system will remain operative after compressor failure, cost of air supply systems, and power consumption of system . . . For assumed combustion control system, calculations show how loadings per day on compressor drop from 5000 for 40-cu ft storage to 560 for 350 cu ft . . . Standard air receivers . . . Should compressor operate continuously or on-and-off? . . . Tankage and pressure combined cause operative time after compressor failure to vary from 2.3 min to 14.3 min at 100 psig. . . . Costs of 100-psig air supply system lower than for 70-psi but power consumption of 70-psi system lower. . . . Although it is based on a combustion control system, this analysis applies equally well to any pneumatic control system

By **D. G. REID** Mechanical Engineer, Sargent & Lundy

INFLUENCE of air storage volume and of initial operating pressure on operation of the compressor and on the time during which the system will remain operative after failure of the compressor, is frequently overlooked, in this writer's opinion, in the design of control systems. Therefore, even though the field covered below is fundamental in nature and the principles well known, the following review of these effects should be of universal interest.

To illustrate the points to be considered, calculations have been made on a hypothetical control system. Actually, the conditions set up for this hypothetical case are not far off from those found in some of the combustion control systems that have actually been installed. While the basis is for a combustion control system, the principles hold equally for any control utilizing pneumatic pressure.

Complete text of paper presented as part of Symposium on Progress in Automatic Control of Steam Plants, conducted jointly by Industrial Instruments and Regulators Division and Power Division, ASME, at 69th Annual Meeting, New York, November 30, 1948.

Conditions Assumed for Control System

Conditions set up for this system are as follows:

1—A constant demand of 90 cfm of free air for the operation of the system. This value is the approximate figure for a system in a central station consisting of 2—50,000-kw turbine genarators and 4 boilers; considering the air used for combustion control, water level controllers, pressure reducing stations, and the like.

2—A compressor of such size that it will operate 60 per cent of the time. This, of course, immediately sets the size of the compressor as 150 cfm actual delivery. It is felt that the figure of 60 per cent operating time is proper, to allow for inaccuracies in calculated demand, sudden demand, and so on.

3—Control of the compressor on a 10-lb pressure range; i.e., the compressor is loaded and unloaded or started and stopped as the pressure falls 10 lb below, or rises to, the nominal operating pressure.

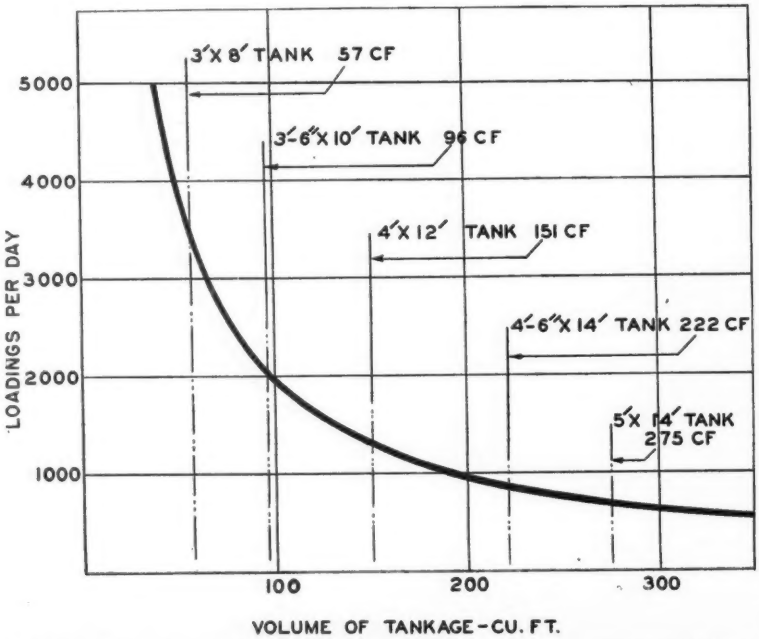


Fig. 1. Curve showing relation of volume of tankage to number of compressor loadings per day. Dot and dash lines represent standard air receiver dimensions and capacities

How Tankage Affects Compressor Startings

Let us look first at the effect of the volume of the storage tankage on the operation of the compressor. The number of loadings or starts of the compressor is materially affected by the storage volume. With a storage volume of 40 cu ft, the number of operations of the compressor per day will be 5000; whereas, with a volume of 350 cu ft, the operations will be reduced to 563.

Figure 1 graphically illustrates this point. The vertical dot and dash lines represent standard air receivers of the dimensions shown. The number of operations of the compressor is affected by the initial pressure but to such a small extent that it cannot be shown on a curve to this scale. Therefore, we can say that Fig. 1 shows the conditions irrespective of the initial operating pressure.

Table showing estimated costs of four air supply systems, for 5-min and 10-min operation, and for 70 psi and 100-psi operating pressure. Assumed: non-lubricated compressor. 440-v motor

System Operating Time—Min.	5		10	
Initial Operating Pressure—Psig.	70	100	70	100
Compressor Size	9" x 9"	9" x 9"	9" x 9"	9" x 9"
Actual Delivery—C.f.m.	155	144	155	144
Compressor Speed—R.p.m.	325	300	325	300
Motor Size—Hp.	40	40	40	40
Motor Speed—R.p.m.	1200	1200	1200	1200
B.H.P. Required	29.5	33.5	29.5	33.5
Receiver Size	5' x 14'	4' x 12'	2—5' x 14'	5' x 14'
Prices				
Compressor	$2685.	$2685.	$2685.	$2685.
Motor	540.	540.	540.	540.
Receiver	1000.	660.	2000.	1000.
Total	$4225.	$3885.	$5225.	$4225.

With even 500 to 600 operations per day of the compressor, the answer to the method of control appears quite obvious. If the compressor is started and stopped at the set pressure limits, then the electrical control equipment is subjected to many thousands of operations per year and the driving motor must withstand the inrush of starting current for this same number of times. Also, most compressors cannot start under load, and the loading and unloading mechanism of the machine undergoes the same operations. On the other hand, if the driving motor operates continuously, then only the loading and unloading mechanism on the compressor is called upon to operate and the wear and tear on the electrical portion of the system is eliminated. Therefore control by loading and unloading the compressor, allowing the driving motor to operate all the time, seems to be definitely indicated.

How Tankage and Pressure Affect Operating Time

When we come to consider the effect of the storage tankage on the time that the system will remain operative after failure of the compressor, we must include the initial pressure and make some additional assumptions as follows:

4—That the system becomes inoperative when the pressure in the storage falls to 35 psig. Most combustion control systems utilize a pressure of approximately 30 psig for the pneumatic cylinders, so the figure of 35 psig in the storage is in line with current practice.

5—That the compressor failure occurs when the pressure in the receiver has fallen to the point where the compressor is just ready to cut in. This assumption is on the conservative side and the failure may just as well occur here, as when the pressure has risen to the point where the compressor is ready to cut out. Consequently, we must consider the time for the pressure to fall from a value 10 psig under the nominal operating pressure, to 35 psig.

Effect of both nominal operating pressure and storage volume on the time that the system can run is shown in Fig. 2. Taking the 100 psig nominal operating pressure curve, you will note that the operating time increases from about 2.3 min with a 3 ft-0 in by 8 ft-0 in receiver having 57 cu ft capacity, to about 11.25 min with a 5 ft-0 in by 14 ft-0 in tank having a volume of 275 cu ft and to about 14.3 min with 350 cu ft storage capacity. On the other hand, a system using 70 psig nominal operating pressure will operate only about 1.1 min, 5.2 min and 6.5 min with the same storage volumes.

Which is Worth More—Tankage or Pressure?

The question of economics of pressure versus tankage naturally arises. Estimated cost for four systems based on non-lubricated type of compressor and 440-volt motor for our hypothetical system is shown in Fig. 3. When operating at 100 psig initial pressure, the 9 by 9 in. compressor is just short of our condition of 150 cfm actual delivery; but the difference is small. All standard air receivers are built for 125 psig working pressure, so that no economy results in the use of a lower pressure from that standpoint. The comparison made here is for 5-min and 10-min operation at initial pressures of 70 psig and 100 psig. Actually, because of the smaller tankage required, the cost of equipment for operation at 100 psig is less than for operation at 70 psig. Also, the incremental cost for an increase from 5-min operating time to 10-min operating time is small, particularly with a 100-psig system.

Power consumption for the 70-

(Continued on page 118)

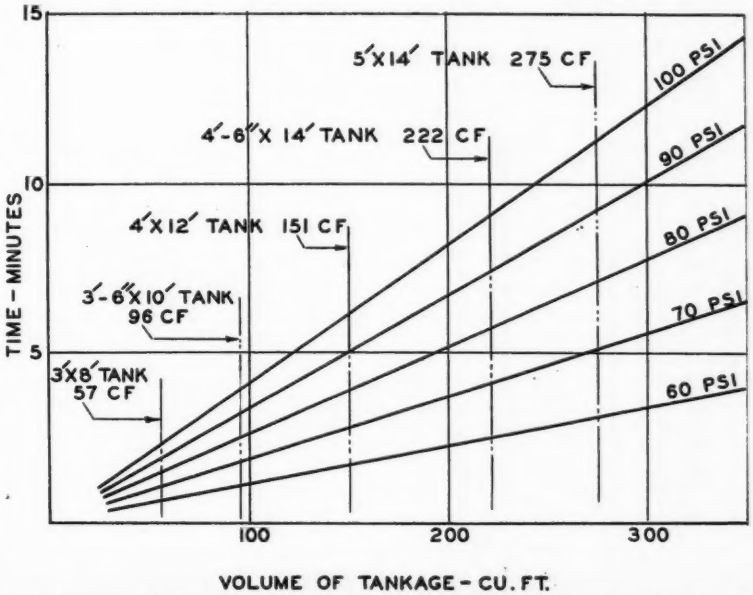


Fig. 2. Curves showing relation of volume of tankage and operating air pressure to time the system can operate after air compressor failure. Dot and dash lines represent standard air receiver dimensions and capacities

Selecting Power Cables to Meet Short-Circuit Requirements

As pointed out by the author, multiple conductor power cable has ample mechanical strength for most conditions but it has limitations so far as heating is concerned. This article shows how to determine the temperature caused by short circuit currents in cables and how to select the proper size and type of cable for various short circuit currents

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A SHORT-CIRCUIT CURRENT in an electric system imposes mechanical and thermal (heating) stresses on all components of the system through which such currents flow. This includes power cable, circuit breakers, current transformers, disconnecting switches, and buses. This article shows how to determine the heating caused by fault-current that cables can safely withstand.

Multiple-conductor power cables possess high mechanical strength because of the compact conductor lay and the continuous concentric armor or lead sheath. No limit on mechanical stresses in such cables have been assigned.

This is not true with regard to thermal effects. In common with other current-carrying parts of the electric system at the time of a short-circuit the abrupt rise in conductor temperature will be limited only by the ability of the conductor metal to absorb the heat developed. The magnitude of the temperature increase is greater (1) as the current magnitude becomes greater (as the square of the current), (2) as the conductor cross-section becomes smaller, and (3) as the duration of current becomes greater.

Temperature Limits

Power-system short-circuit current magnitudes, feeder-conductor cross section, and protector interrupting time should be co-ordinated to avoid severe permanent damage to cable insulation during the time fault-current exists in the system. The effect should be limited to a moderate reduction in useful cable life (approximately one per cent of normal life).

Reasonable maximum-peak transient temperatures for various cable insulations and operating potentials in general are approximately 150 C (see Table I). At a slightly higher temperature (approximately 175 C) destructive disintegration of organic materials may occur, accompanied by smoke and combustible vapors. At somewhat higher temperatures large quantities of combustible vapors are expelled which increases the risk of explosion and fire.

It is important to note that the abnormal temperature persists much longer than the duration of fault-current. For example, a current of 20,000 amp in a No. 4/0-Awg copper conductor will increase the copper temperature from an initial temperature of 75 C to 150 C in about 1/3 second. With the current then reduced to zero, about 1000 seconds will be required for the copper temperature to return to 75 C in a 30 C ambient.

Conductor Heating

On the basis that all heat produced by fault current is initially absorbed by the conductor metal (which has been proved to be valid for conduc-

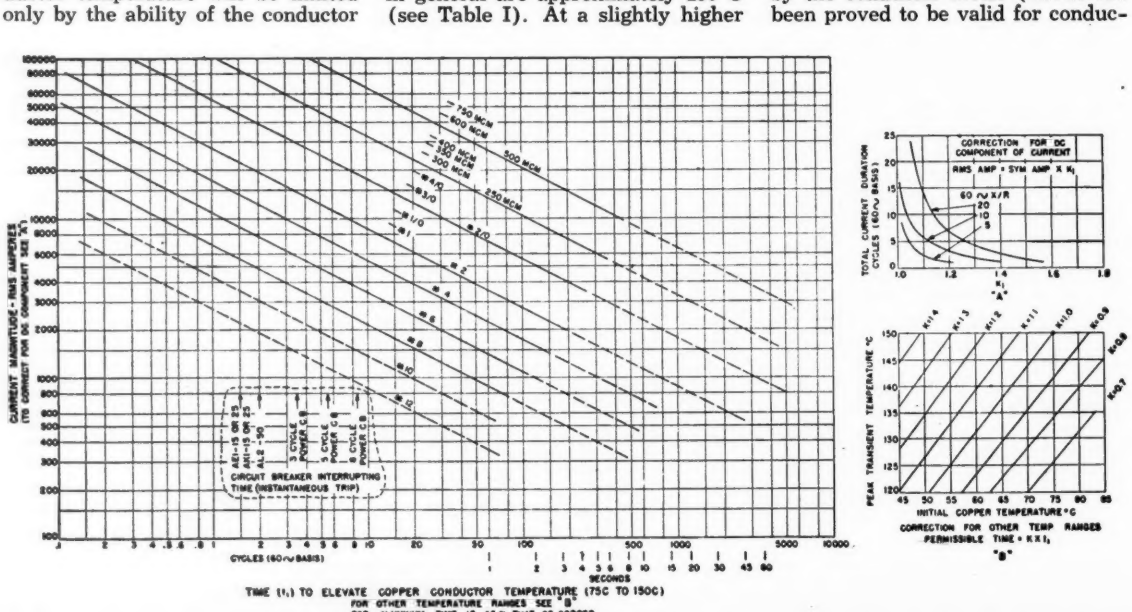


Fig. 1. Short-time (short circuit) heating limits of copper cables and correlations of current and time to raise the copper temperature from 75 C to 150 C (all heat stored in the copper)

tor sizes of No. 8 Awg or larger[1]), the conductor heating is governed by:

FOR COPPER

$$\left(\frac{1}{cm}\right)T_2 = \frac{1}{33}\log_{10}\frac{(T_2 + 234)}{(T_1 + 234)} \text{ or}$$

$$t = \frac{1}{\frac{I^2}{cm}(33)}\log_{10}\frac{(T_2 + 234)}{(T_1 + 234)}$$

t = Duration of current (seconds)
I = Rms amperes during the entire interval of current
cm = Conductor cross section (circular mils)
T_1 = Initial copper temperature (C)
T_2 = Final copper temperature (C)

To simplify application, these relationships are presented graphically in the large chart, Fig. 1. The permissible time for various temperature ranges can be quickly evaluated with the aid of the auxiliary curve B, shown in Fig. 1. For quick estimating purposes, minimum safe conductor size is given in Table II, subject to application conditions as shown.

FOR ALUMINUM

Since service experience with insulated aluminum-conductor power-cable is very limited, the problem of transient heating should be approached with caution, and particular attention given to possible accentuated thermal distress at joints and terminations.

In the absence of abnormal local heating, a rough approximation of permissible current duration may be made on the basis of the same limiting temperatures as for copper. (For a particular current and conductor cross-section, the permissible duration of current will be 45 per cent of that for copper.) It may be more convenient to make an artificial correction in current. Consider the current to be 150 per cent of the actual value and proceed on the chart as if the conductor were copper.

RMS Current

Rms current as used here is defined as the root mean square value for the total time of current. The temporary direct-current component encountered in a-c circuits increases the rms current but to a lesser extent as the interval of flow becomes longer. The appropriate factor (K_1) by which the symmetrical current value shall be multiplied to determine the true rms current is given in chart A, Fig. 1, for several typical ratios of circuit 60-cycle reactance to resistance (distribution circuits will generally fall in the region of $x/r = 10$ or less).

Circuit x/r ratio is generally not known and requires numerous circuit constants for an evaluation.

[1] AIEE Tech. Paper "Short-time Current Ratings for Aircraft Wire and Cable" B. W. Jones and J. A. Scott, 1946.

Table I.—Cable Conductor Rated Maximum Continuous Operating Temperature and Peak Transient (Momentary) Temperature as Defined by the Cable Division for Various Types and Operating Voltages

Cable type	Voltage Class (Kv)	Max con't** Copper Temp (C)	Max Transient Copper Temp (C)
Vc type V or VL	1	85	150
1/c or 3/c	4.5	85	145
	7.5	84	135
	15	77	120
Impregnated paper (solid) 1/c	1	85	150
	4.5	85	145
	7.5	85	140
	15	81	135
Impregnated paper (solid) 3/C	1	85	140
	4.5	85	135
	7.5	85	130
	15	81	125
Type R*	1	60	140
	5	60	135
	8	60	130
	15	60	125
Type RH	1	75	150
	5	75	145
	8	75	140
Coronol	1	80	150
	5	80	145
	8	80	140
	15	80	130

* Applies to new type R (1947 code specification)
** Actual operating temperature may be lower due to conservative application or a favorable ambient temperature

Conservative factors (K_1) for the more common application conditions are:

Low-voltage circuit breakers tripped instantaneously (AE-1-15, AE-1-25, AL-2-50) $K_1 = 1.25$
Power circuit breakers, 8 cycle, instantaneously tripped $K_1 = 1.1$
Any industrial power-distribution problem with current duration of ½ second or more $K_1 = 1.0$

Circuit Protector Interrupting Time

(1) Circuit breakers

The minimum time duration of current in a circuit protected by a circuit breaker tripped by an instantaneous element will vary with the type of circuit breaker used. Typical values for G-E circuit breakers are shown in the lower left-hand corner of the large chart in Fig. 1.

When interruption is purposely delayed by time-delay relays or time-delay trip coils, the duration of current will be governed by the time-delay relay or trip coil plus the inherent delay in the circuit breaker.

(2) Fuses (current-limiting)

Current-limiting fuses (Type EJ high and low voltage and National Electrical Code low voltage) tend to progressively limit the time interval of current flow to lesser values as the magnitude of current increases. As the current magnitude increases toward the maximum interrupting ability of the fuse, the magnitude of I^2t tends to approach a constant value. This is equivalent to a fixed temperature rise in a particular size of conductor. Data accumulated to date indicates that a fuse (of the types mentioned in this paragraph) whose ampere rating is not greater than 1.5 times the conductor continuous-current rating will protect against dangerous conductor temperatures for severe overcurrents up to the maximum interrupting rating of the fuse.

(3) Fuses (non-current-limiting)

Non-current-limiting fuses accomplish current interruption at a normal current zero and thus the current conduction time cannot be reduced below that of the first current loop of fault current flow which may be as much as about one cycle of the power frequency. Applications should thus recognize one cycle as the minimum time of fault-current flow.

Application Procedure

(1) Evaluate the symmetrical current or currents that may be critical
(2) Define protective device clearing time at this or these current magnitudes
(3) Apply rms correction factor to allow for the d-c component for each time interval involved
(4) Make an initial check on the current-time chart for the smallest conductor size being considered (permissible time should exceed protector interrupting time)
(5) If critical, it is advisable to correct for the exact temperature range (see Table I and temperature range correction curve)
(6) If an oversize conductor is considered, but the continuous load current is to remain fixed, advantage can be taken of the

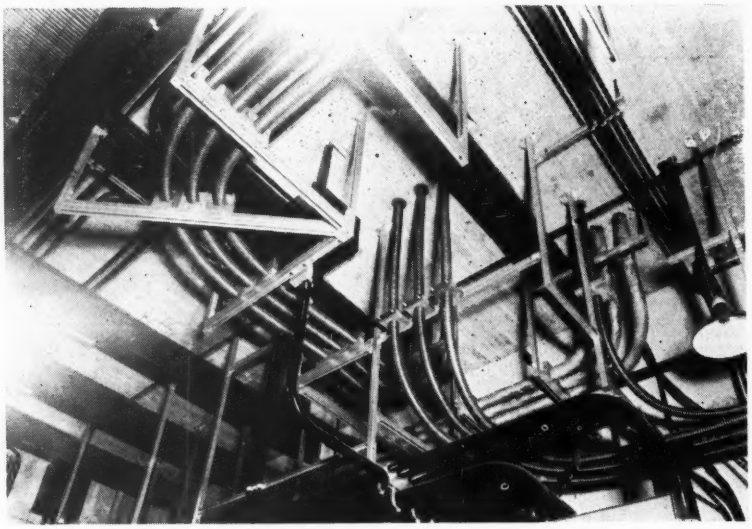


Fig. 2. An interesting installation view of a-c power cables

lower initial conductor temperature.

Examples

EXAMPLE 1

A transformer feeder cable is being selected to accommodate a 1000-kva, 2.4-kv transformer. The rated current of the transformer (240 amp) indicates a cable conductor of 250 MCM. The transformer in question is good for full short-circuit current (16 times normal) for 5 seconds. It is desired that the feeder cable have the same ability.

SOLUTION

Rms symmetrical amperes = Rated current × 16 = 240 × 16 = 3900 amp. The duration of this current as defined by the conditions of the problem is 5 sec.

Assume x/r ratio = 10 or less

From chart A of Fig. 1, $K_1 = 1$ (x/r ratio of 10 and time of 5 sec)

Hence, the total rms amp affecting cable heating = $K_1 \times 3900 = 1.0 \times 3900 = 3900$ amp.

On the large chart of Fig. 1, locate the intersection of the horizontal 3900-amp line and the 250-MCM conductor diagonal line. The permissible time (read on the bottom scale) is indicated to be 12 sec (75 - 150 C basis)

The 250-MCM cable will adequately meet the 5-sec requirement.

EXAMPLE 2

Feeder circuits are to be run from a 480-volt 60-cycle load-center unit substation at which point the short-circuit duty is 25,000 amp (20,000 symmetrical rms amp). What is the smallest reasonable feeder conductor size based on the use of an AE-1-25 air circuit breaker which trips instantaneously (1½ cycles) at currents in excess of 15 times the normal rating?

SOLUTION

Symmetrical current = 20,000 amp

Time duration = 1.5 cycles

Rms amp = 20,000 (1.25) = 25,000

See text for explanation of 1.25 factor K_1

On the large chart of Fig. 1, locate the intersection of the horizontal 25,000 amp line and the vertical 1½ cycle line. The minimum size conductor (75 = 150 C basis) whose curve is above the intersect is a No. 1 Awg.

EXAMPLE 3

A 4-kv feeder is to be run from a substation at which the symmetrical fault current is 25,000 amp. A continuous load capacity of 1000 kva is desired (143 amp) and a No. 2/0 Awg coronal cable run is being considered. Line relaying is to consist of standard IAC relays on 4 amp tap No. 5T.L.S. with 250/5 amp current transformers. Instantaneous attachments are not planned, but could be used if set at 3000-amp line current.

SOLUTION

Symmetrical current = 25,000 amp

Case I. No instantaneous attachment on relay

Rms symmetrical fault current = 25,000 amp

Relay operating time = 50 cycles (See IAC relay time-current curves in Switchgear Handbook Section.)

Circuit breaker operating time = 8 cycles

Total time = 50 + 8 = 58 cycles

Assume x/r ratio of 15 or less

From Chart A of Fig. 1, $K_1 = 1$

Hence, total rms amp affecting cable heating = $K_1 \times 25{,}000 = 1.0 \times 25{,}000 = 25{,}000$ amp

On the large chart of Fig. 1, locate the intersection of the 25,000-amp horizontal line and the 58-cycle vertical line. The smallest conductor whose curve lies above this intersect is a 500 MCM. Therefore, a No. 2/0-Awg MCM conductor is very inadequate.

Case II. Instantaneous attachment on relay set to operate at and above 3000 line amp.

Two points must be checked: (1) a current of 3000 amp and time delay of IAC relay (just below the operating current of the instantaneous element) and (2) the maximum current with instantaneous relay operation.

(1) From published IAC data, the relay time at 3000 line amperes is 66 cycles; circuit breaker time 8 cycles; making a total time of 66 + 8 or 74 cycles.

From Chart A of Fig. 1 for x/r ratio of 10 and time of 74 cycles, $K_1 = 1$.

Total rms amp affecting cable heating = $K_1 \times 3000 = 1.0 \times 3000 = 3000$ amp.

The intersect of 3000 amp and 74 cycles on the large chart of Fig. 1 shows that a No. 2/0 Awg conductor is amply large to carry the 3000 amp for 74 cycles.

(2) At the maximum current, instantaneous relay operation will be obtained.

Fig. 3. High-voltage industrial plant feeder cables shown leaving the main sub-station metal-clad switchgear

The total current duration will be the relay time ½ cycle plus circuit breaker time 8 cycles or 8½ cycles.

For 8½ cycle time interval $K_1 = 1.1$ (See Text).

Total rms current affecting cable heating $= K_1 \times 25{,}000 = 1.1 \times 25{,}000 = 27{,}500$ amp.

The intersection of the 27,500 amp horizontal line and the 8½ cycle vertical line on the large chart of Fig. 1 indicates a No. 4/0 Awg conductor (75 - 150 C basis), and shows that point (2) controls the cable size.

However, a No. 4/0-Awg conductor would operate at less than rated temperature. A specific check may show that a No. 3/0 Awg conductor is adequate.

Rated conductor temperature coronol cable = 80 C (See Table I) ambient temperature = 40 C. Normal temperature rise produced by rated current = 80 — 40 = 40 C.

Rated continuous current for No. 3/0-Awg coronol cable = 185 amps. The temperature rise will be roughly proportional to the square of the current.

Hence, the normal conductor temperature of a No 3/0 Awg operating at 143 amp would be expected to be

$$\frac{143^2}{185}$$

(Rise at rated current) + ambient =

$$\frac{143^2}{185}(40) + 40 = 63.8 \text{ C or } 64 \text{ C}$$

The maximum momentary temperature for coronol at 5 kv is 145 C (See Table I).

From detail Chart B, Fig. 1 the correction factor K for an initial conductor temperature of 64 and final of 145 is K = 1.13.

From large chart of Fig. 1 the permissible time for 27,500 amp in No. 3/0 conductor (75 - 150 C basis) is 6.7 cycles.

The permissible time corrected to a 64 - 145 basis is $K \times 6.7 = 1.13 \times 6.7 = 7.6$ cycles.

Therefore, a No. 4/0-Awg conductor is the correct selection since a No. 3/0 Awg conductor would fail to meet the 8.5 cycle requirement.

EXAMPLE 4

An underground feeder duct run is being planned from a 13.8-kv bus using a 3-conductor No. 2/0 Awg. VCL shielded cable to carry 4000 kva, (175 amp) at 75 per cent load factor, with 3 loaded cables per duct bank, and the earth ambient is 20 C. An 8-cycle circuit breaker is to be used equipped with IAC relays with instantaneous attachments set at 1750 line amp. The short-circuit duty at the 13.8-kv bus is 500,000 kva.

Continuous rating of 2/0 Awg 3-conductor cable (77C conductor temperature) is 185 amp. Permissible transient temperature 120 C (See Table I).

Check the short-circuit current ability of No. 2/0 Awg cable at maximum short-circuit current.

SOLUTION

The rms symmetrical current associated with 500,000 kva short-circuit duty at 13.8 kv is:

$$\text{rms symmetrical amp} = \frac{500{,}000}{13.8\ \ 3}$$

$= 20{,}800$ amp

Total duration = relay time (½

(Continued on page 118)

Table II. Quick estimating table of minimum conductor size

Based on: Copper conductor. 75 C conductor temperature rise (75-150C). A single interval of fault-current conduction. Constant current after 1/10 second

A. Low-voltage Air Circuit Breaker Protection
Duration of Fault Current

"IC" (Amperers) (1.25 x Symmetrical)	1.5-2 Cycles (Inst Trip)	¼ Second	½ Second
5,000	No. 8 Awg	No. 4 Awg	No. 2 Awg
10,000	No. 4 Awg	No. 1 Awg	No. 1/0 Awg
15,000	No. 2 Awg	No. 2/0 Awg	No. 3/0 Awg
25,000	No. 1 Awg	No. 4/0 Awg	300 MCM
35,000	No. 1/0 Awg	300 MCM	400 MCM
50,000	No. 3/0 Awg	400 MCM	600 MCM
75,000	300 MCM	600 MCM	800 MCM
100,000	350 MCM	800 MCM	1000 MCM

B. High-voltage Power Circuit-breaker Protection

"IC" Amperes (1.0 x Symmetrical)	Interrupting kva at: 2.4 kv	4.16 kv	6.9 kv	13.8 kv	Duration of Fault Current: 8.5 Cycles (Inst Trip)	½ Second	1 Second
3000-3500		25 MVA		75 MVA	No. 6 Awg	No. 3 Awg	No. 2 Awg
3500-4000					No. 4 Awg	No. 3 Awg	No. 1 Awg
4000-4500			50 MVA		No. 4 Awg	No. 2 Awg	No. 1 Awg
4500-5000					No. 4 Awg	No. 2 Awg	No. 1/0 Awg
5000-6000					No. 2 Awg	No. 1 Awg	No. 2/0 Awg
6000-7000	25 MVA	50 MVA		150 MVA	No. 2 Awg	No. 1 Awg	No. 2/0 Awg
7000-8000					No. 2 Awg	No. 1/0 Awg	No. 3/0 Awg
8000-9000			100 MVA		No. 1 Awg	No. 2/0 Awg	No. 3/0 Awg
9000-10,000					No. 1 Awg	No. 2/0 Awg	No. 4/0 Awg
10,000-12,500	50 MVA	75 MVA		250 MVA	No. 1/0 Awg	No. 3/0 Awg	250 MCM
12,500-15,000		100 MVA		350 MVA	No. 2/0 Awg	No. 4/0 Awg	300 MCM
15,000-17,500					No. 3/0 Awg	250 MCM	350 MCM
17,500-20,000	75 MVA				No. 3/0 Awg	300 MCM	400 MCM
20,000-25,000	100 MVA	150 MVA	250 MVA	500 MVA	No. 4/0 Awg	350 MCM	500 MCM
25,000-30,000					250 MCM	400 MCM	600 MCM
30,000-35,000		250 MVA		750 MVA	300 MCM	500 MCM	750 MCM
35,000-40,000	150 MVA		500 MVA		350 MCM	600 MCM	750 MCM

74-Wheel Trailer Carries 100,000-kw Generator

THE SECOND of two 100,000 kw General Electric turbine generators for installation in Station "P" of the Pacific Gas & Electric Co, which was delivered recently will make Station "P" one of the strongest links in the PG&E power generation chain. The installation of these units is part of a huge post-war expansion program being carried on by the Company. Before the end of 1951 many other turbine-generator units will be added and nearly two million additional horsepower supplied to the system.

A development of many years' research and improvement in turbine manufacture, the 100,000-kw Station "P" units are the first of their type west of the Mississippi.

The shipment of the first of these two units set a record as one of the largest single shipments ever recorded. Due to the large size and great weight of the parts—the gigantic armature, largest single piece of the installation, weighs more than 355,000 lb—it was necessary to construct a special freight car and route it circuitously. This car has eight axles and 16 wheels as compared to the usual four axles and 8 wheels. Roundabout routing was necessary because of weight limitations and clearances along the regularly travelled cross-country tracks, as a consequence, the distance travelled was almost twice as long as that on the usual transcontinental trips.

When the generators arrived in San Francisco, five days were required to transfer the armature from the freight car to a trailer built for the occasion by the Thomas Drayage

Fig. 1. (Above.) A rear view from above of the armature moving up the Bayshore Highway Hill, showing four of the five towing trucks.

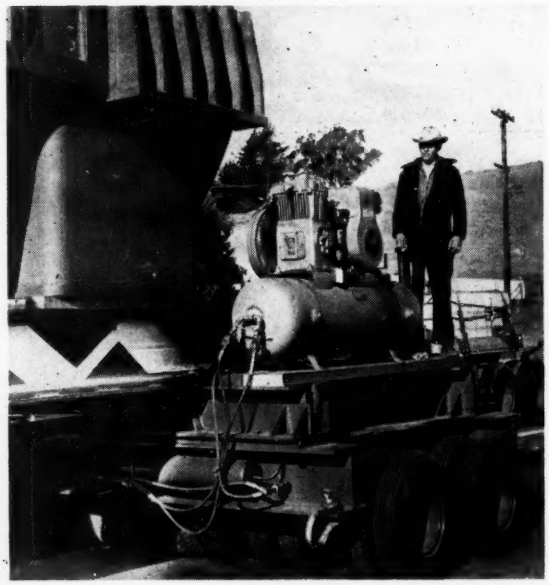
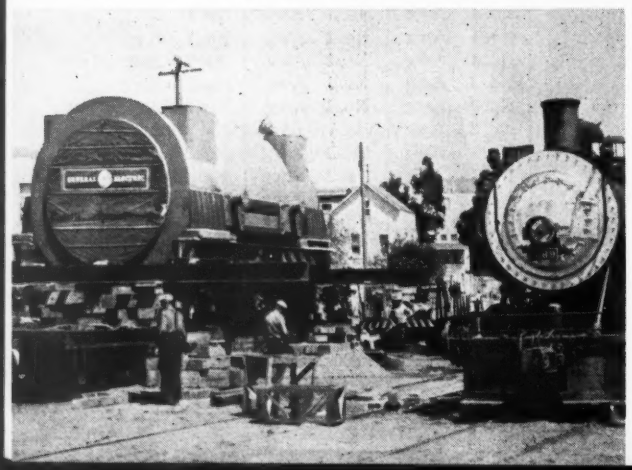


Fig. 3. The special air compressor mounted on the rear section of the trailer, with the brakeman at the controls. This air compressor supplied air to the air brakes on the 32 wheel back trailer. During the entire trucking operation a brakeman was riding this position

Fig. 2. (Below) The armature being jacked up from the flatcar at the delivery siding. A steam locomotive alongside gives a good comparison of size.



Co. This trailer had to be equipped with 14-ply tires on all of its 74 wheels.

The load required seven trucks, whose power ratings totalled more than 1000-hp, to move it up some of the hills on the route. Five trucks pulled and two pushed the giant trailer. At one point in the trip, it was necessary to mount a motor-driven winch at the top of a hill to assist in braking the armature down the steep highway. A special air compressor was mounted on the rear section of the trailer to supply air to the brakes.

Even though there is a railroad siding directly into the power station, it was necessary to haul the load through the city by trucks because the tunnels along the rail route were not big enough to let the armature through.

The distance covered through the city was only eight miles, but nearly eight hours were required for the trip, slightly more than one mile per hour being all the load could average.

Five other units of similar size are on order for PG&E for two new plants in the Bay area.

World's Most Powerful Motor Drive

THE WORLD'S LARGEST supersonic wind tunnel, capable of producing winds of about 1500 mph, was unveiled in Cleveland recently by the National Advisory Committee for Aeronautics. The entire drive, including motors, controls, and switchgear, was designed and built by General Electric.

Features of the tunnel are an axial-flow air compressor with over a thousand blades; the most mechanical power ever placed on a single shaft by electric motor drive; and the three largest slip-regulators yet devised.

Wind is created by the air compressor when it is driven by three 29,000-hp electric motors hooked in tandem to a single drive shaft. The motors, which operate at 900 rpm, are the largest ever built to run at that speed. Their 87,000-hp total is the greatest ever used in a wind tunnel installation. Designed and built by General Electric, the motors are wound-rotor, 8-pole, 6600-v, induction motors using 3-phase, 60-cycle power from standard lines.

Efficiency rating of the motors is approximately 97 per cent, but even at that rate, they lose 2610-hp at normal operating speed. Special insulation on the motors is capable of carrying a temperature rise of 80 C at continuous rated load.

Totally enclosed, the motors are fitted with water-to-air heat exchangers and axial-flow blowers for cooling. Although running in tandem mechanically, they are hooked up in parallel electrically.

Current in the motors is so high that it is necessary for the stators to be connected to a three-phase transformer. Circuit breakers are located in the primary winding. This allows the motor-transformer combination to be switched in as a unit.

Stable operation of the motors is insured by slip-regulators of the liquid rheostat type. Due to the size of the motors it was necessary for G-E to build regulators that are physically the largest, carry the highest electric current, and dissipate the greatest amount of power, of any ever designed. Tanks large enough to fit these regulators were too large for any existing freight car, so it was necessary to build three tanks for each regulator, one tank for each phase of the current. Each tank is about 20 feet high.

Each of the three drive motors is governed by its own regulator with the regulator for the first one acting as a master, the other two acting as followers. Each regulator consists of movable electrodes connected mechanically to a hoist mechanism and electrically through an electrolytic salt solution to form a "Y" and neutral circuit external to the motors.

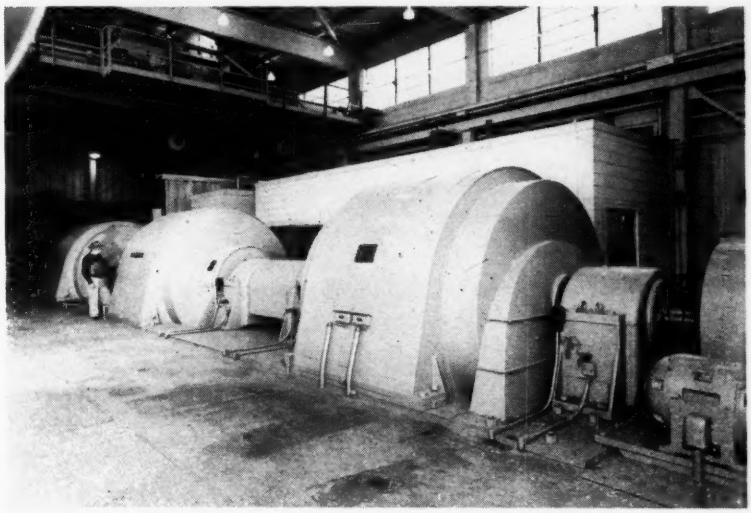


Fig. 1. Showing the three 27,000-hp G-E motors connected to their drive shaft. This represents the most mechanical power ever applied on a single shaft by an electric motor drive

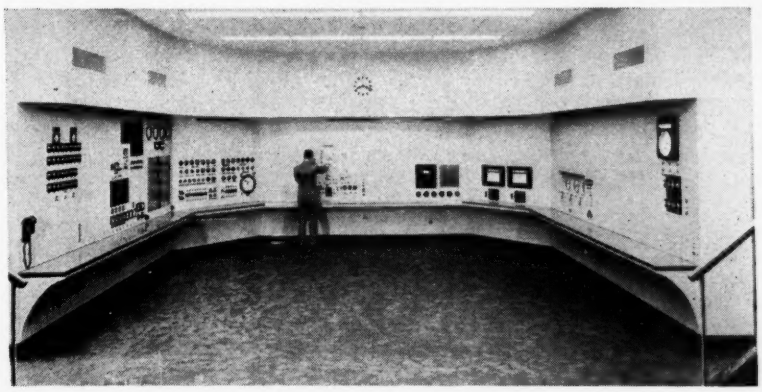


Fig. 2. Showing the control room of the giant wind tunnel at Lewis Memorial Laboratory in Cleveland. This NACA-sponsored tunnel is the world's largest supersonic wind tunnel

Need Reserve Coal Storage Now?

If so, or if you believe conditions are again approaching when you will need it, here are the principal ways to provide it at minimum cost. . . . How to prepare site. . . . Weathering losses. . . . Use of drag scraper, bulldozer, carry-all, belt conveyors. . . . Spontaneous ignition in storage. . . . Anthracite easier to store than bituminous, but be gentle with it. . . . Coal dust explosion hazards after you get the coal into the handling system

By **WILBUR G. HUDSON** Consulting Engineer

AT THE HEIGHT of the war, coal storage became a matter of supreme importance because of the demands on rail transportation. Industrial and utility plants became actively concerned with reserve storage; and with stocking out and reclaiming methods that would keep handling costs and losses at a minimum. At the present time, unfortunately, conditions seem to be again approaching when emergency storages will have to be set up.

Such storages, to a considerable extent, cannot be in the immediate vicinity of the plant for which the coal is intended. The plant caterpillar crane and grab bucket will normally be available. It can function to best advantage along any available siding from an off-set pit into which the cars are discharged, the bucket forming a pile from which a bulldozer can spread the coal. To reclaim, the process is reversed, with the bucket loading direct to the cars.

Site Preparation

A capacity of 70 tons per hour, in or out, is easily maintained. When the area has been filled, the crane and bulldozer return to their regular duties. The only investment is in the track hopper pit and preparation of the site.

This preparation of the site is important. Miscellaneous wood, rags, straw, and the like, will cause trouble unless the reclaimed coal is passed through a hammermill or Bradford breaker that can be relied on to cull them out. The author recalls a utility company storage plant at Shadyside, N. J., across the Hudson from Manhattan, where part of the fill was discarded building scrap with a mixture of un-slacked lime. That section of the coal pile gave considerable trouble with spontaneous ignition, probably initiated by the heat generated as the lime slacked.

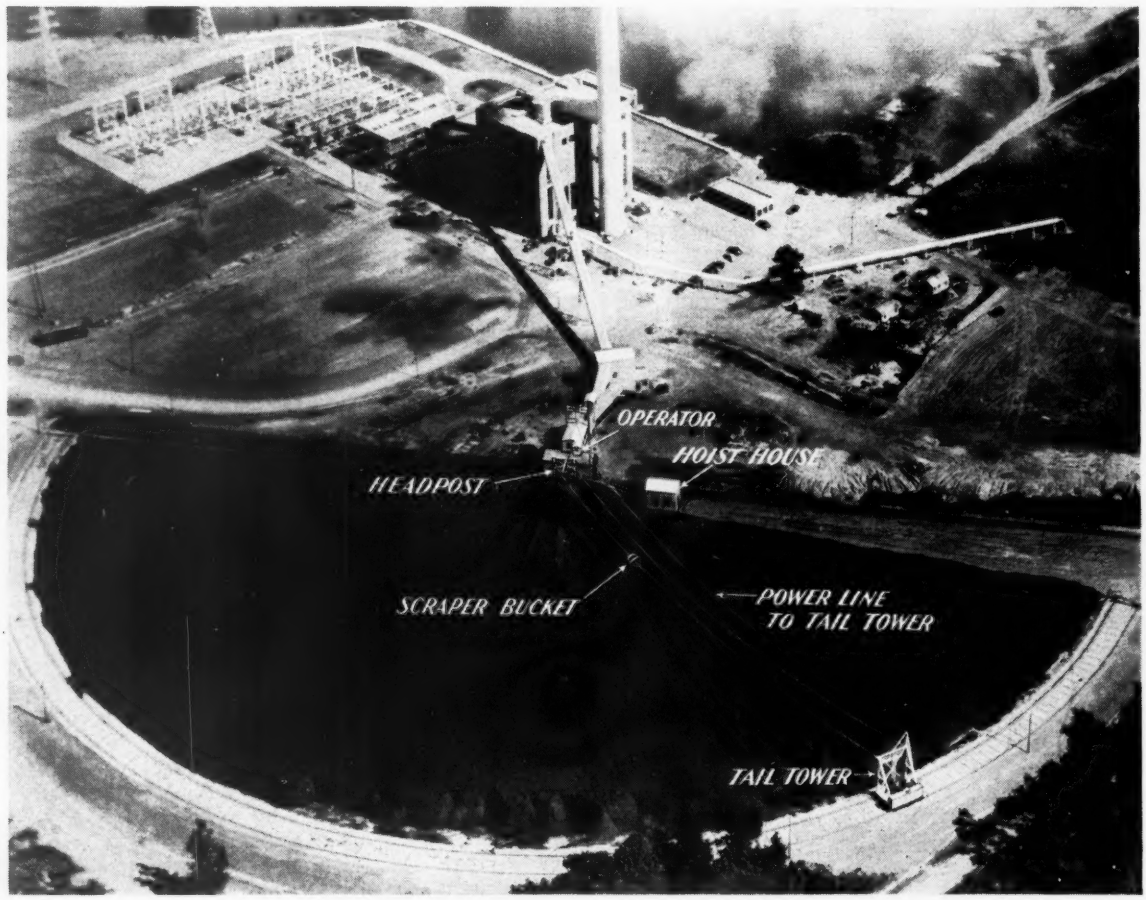


Fig. 1. Typical drag scraper system of reserve coal storage for power plant

Undesirable procedures are pretty well recognized. If coal is dropped from a grab bucket and piled up, the nut or fragments roll down the flanks, while the fines pack at the peak. Air enters through the lumpy coal, oxidation begins, with rise of temperature increasing the rate of oxidation, and, unless the air circulation is sufficient to carry off the heat, ignition may follow. The obvious correction is to spread and roll the pile in layers, preferably of 6 in. or 8 in. depth, to eliminate air circulation.[1]

Weathering in Storage

In a secondary or emergency reserve storage, which probably will remain untouched for several years, it may be desirable to further protect the pile against weathering and dust loss by a sealing agent[1] such as emulsified asphalt. However, loss due to weathering is slight. There may be some difficulty in firing "stale" coal, but this can be corrected by mixing in a percentage of fresh coal when reclaiming to the bunker.

Research by the U. S. Bureau of Mines with New River, Pocahontas, Pittsburgh Gas and Sheridan Wyoming coals showed losses from outdoor weathering no greater than 1.2 per cent in the first year, and 2.1 per cent in two years. The sub-bituminous Wyoming coal showed losses up to 3 per cent in the first year and 5 per cent in five years. In Appalachian coals, oxidation starts at about 85 F, and increases in rapidity with temperature increases. The starting temperature is lower with lower grades. The presence of pyrites is a contributing factor as, of course, is the exposed coal surface area. For instance, 3 in. nut has a surface area of about 500 sq ft per 40 cu ft. With ⅜ in. x 0, this may increase to 4000 sq ft per 40 cu ft.

Drag Scraper Systems

Simplest and sometimes least costly equipment for stocking out and reclaiming coal that does not need to be compacted is the drag scraper as shown in Fig. 1. It does not require the mechanical skill and training of a bulldozer or grab bucket operator and is readily furnished for the capacities involved in a plant of moderate tonnage consumption.

The trend at larger plants has been toward the track-type bulldozer and the carryall. The treads do grind up the coal and, when it is rained upon, the wet pulverized material causes trouble by arching in the bunker and chutes. This arching is particularly troublesome with the smallest steam sizes—⅜-in. and smaller. Extensive research by the Consolidated Gas, Electric Light and Power Co. of Baltimore, described[2] in POWER

[1] Coal Storage Manual; POWER PLANT ENGINEERING; July 1942.
[2] Flow of Coal in Chutes, by E. F. Wolf and H. L. von Hohenleiten; POWER PLANT ENGINEERING; July, 1945.

Fig. 2. Carryall for handling coal in storage system. These carryalls are made with capacities up to 30 cu yd if desired

Fig. 3. System employing 36-in belt conveyor for transporting coal from wharf through 200,000-ton storage area. Coal reloaded by crane to movable hopper, which feeds it back to belt

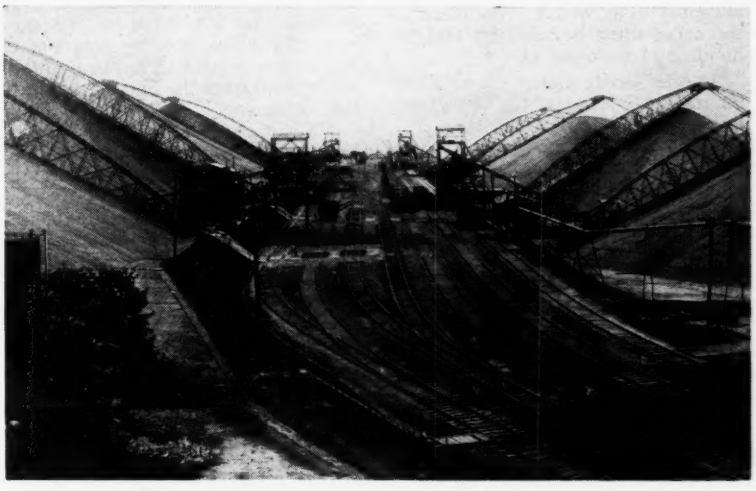


Fig. 4. Anthracite storage plant of 500,000 tons capacity

PLANT ENGINEERING and in the October, 1945, *Transactions of the ASME* has led to recommendations regarding the shape of chutes feeding to the pulverizers that give promise of much better flow. The problem still, however, is to get it out of the bunker.[2 and 3]

Bulldozer and Carryall

The bulldozer is strictly a pusher. It pushes the load ahead, spills some around the edges of the blade and replaces the spillage as it moves forward. This might be regarded as giving poor operating efficiency. However the blade operates largely in a self-made trough, which reduces the side spillage. The machine is usually used for trips not more than 200 ft out and back. Handling capacities range from 50 tons per hour on a 200-ft push to 135 tons per hour on a 50-ft push. A 100-hp motorized unit will show an operating cost, including labor, depreciation, interest, insurance, fuel and oil and up-keep, of about $5 per hour.

The carryall, Fig. 2, is a self-loading, self-discharging carrier towed either by a track-type or rubber-tired prime mover. It is rather costly —$15,000 to $20,000 for a 10-ton capacity machine with 100 hp tractor. It is built in standard sizes up to 30 cu yd capacity. Operations may dictate the use of both machines—the bulldozer shaping up the loads deposited by the carryall.

Belt Conveyor Systems

Waterborne cargoes on the Great Lakes are frequently carried by self-unloading vessels, with a belt conveyor in a tunnel along the keel, an elevator at the bow, and a swinging boom belt conveyor above the deck. These self-unloaders normally have a handling rate of 1000 tons per hour or more. The *S. S. Crispin Oglebay* has a normal unloading rate of 2,400 tons per hour with 48-in. belts and elevator buckets 8 ft long. These discharge rates are altogether too great for on-shore distributing equipment, except with excessive investment, so the cargo must be piled up and re-handled at a slower rate.

At the Great Lakes Steel Corp. plant, Fig. 3, an open top suspension bunker of 7000 tons capacity is provided at the wharf to receive the cargo. From the bunker the coal feeds to a 36-in. belt conveyor with Weightometer, then to 36-in tandem belts bisecting the storage area, with stacker trippers that pile the coal along either side for re-handling by grab bucket to provide 200,000 tons storage. Coal is reloaded to the belt for transfer to the plant bunkers. The 36-in. belts have a capacity of 500 tons per hour. The vessel unloads about 9,800 tons in 7 hours. During this time, 3,500 tons have been removed from the bunker, so a minimum bunker capacity of 6,300 tons is indicated.

It will be noted in Fig. 3 that the conveyors are depressed below ground level. This gives protection against high cross winds lifting the belt from the idlers, and the side walls conveniently support the insulator brackets of the feed wires, while forming a support for the rails of the travelling hoppers. The coal does not heat and so is not compacted.

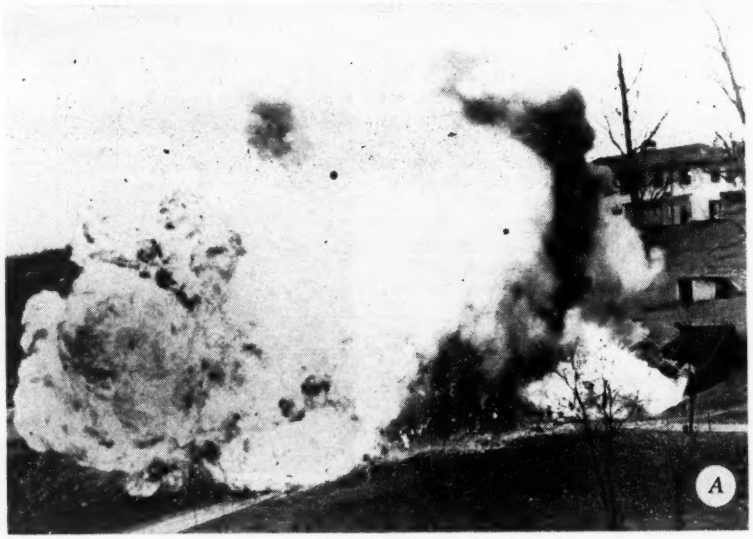


Fig. 5. View showing violence of explosion of 200 lb of coal dust in experimental mine of U. S. Bureau of Mines

Causes of Spontaneous Ignition

Returning to the subject of spontaneous ignition, if air circulation is prevented there is little likelihood of trouble.[1] The author recalls that the theory once generally held was that heating was caused by pressure, and the rule was never to store coal deeper than 30 ft. One Boston plant had an unusually deep bunker—about 45 ft—and whenever it was well-filled, the coal started to ignite near the bottom. The bunker was encircled by a pivoted bucket carrier, and when heating was noted, the conveyor was kept in operation taking coal from the bottom and putting it on top.

We know now that pressure due to depth had nothing to do with the heating. Some air filtered up through the bunker gates, but the chief cause of oxidation no doubt lay in the segragation of sizes. The nut, rolling down along the flanks of the bunker as the carrier buckets emptied, provided a flue down which the air flowed to contact the fines in the lower central section, where heating always started.

Layer storage piles must be compacted along the edges, otherwise these sections offer a good starting point for trouble. The normal angle of repose is too steep for the track-type treads to navigate, but after the spreading and compacting are completed, the bulldozer is free to flatten down and compact the fringes.

When heating does occur, it is usually within the first three or four months. Temperature tests are readily made by inserting rods into the heart of the pile for an hour or two, then noting by feel the temperature of the rod throughout its length. If a danger spot is found, that section may be dug out, or wet down. This means getting the water right down into the hot spot, not just sealing up the roof over the section which has ignited and which, in a day or two, will be dried out and useless.

Anthracite Storage

Anthracite storage does not involve the difficulties encountered with bituminous coal. The chief factor is gentle handling of the domestic sizes to minimize breakage into sizes commanding a lower price. There is no tendency to heat in storage. Great storage plants are maintained by the producers somewhere along the line between the preparation plants and the markets served. The coal is formed in conical piles by conveyors, which progressively discharge just above the peak of the growing pile, and is reloaded to cars by a reversible horizontal run-around conveyor carried in a frame resting on circular ground level tracks. Each reloader covers a sweep over the area of the bases of two adjoining piles. Figure 4 is a view of a typical anthracite storage plant. It is of 500,000 tons capacity, located near Norristown, Pa. and operated by the Philadelphia & Reading Coal & Iron Co.

Dust Explosions in Handling Systems

It may not be out of place to mention the growing realization of the

(Continued on page 120)

[3] Under-Bunker Conveyors; by A. V. Stock; POWER PLANT ENGINEERING; June, 1946.

Moving Six Marine Boilers To Texas City

By J. R. BUSS
Assistant Manager, Power Section
General Engineering Department
Monsanto Chamical Co.

MANY PEOPLE will recall the explosion of the steamer "Grandcamp" on April 16, 1947, at Texas City, Texas and the resulting fire which completely destroyed the nearby plant of the Monsanto Chemical Co. The plant resumed operation last month with the first car-lot shipment of styrene monomer, on schedule.

Behind the accomplishment, of course, were the planning and hard work of many people. But when the Monsanto officials announced soon after the disaster that the plant would be rebuilt on the site procurement, design and construction problems of considerable magnitude were placed upon the Engineering staff in particular. Among them was the replacement of a boiler plant which was a shambles.

With the prevailing length of time required for engineering and fabrication of new boilers for a plant to have a steam capacity of 150,000 to 200,000 lb per hr, it was apparent that new equipment could not be obtained and installed in anything like the time required by the established rehabilitation schedule. It was essential that second-hand equipment be obtained.

A survey of the second-hand boilers available did not disclose suitable units of the conventional designs for stationary boiler plants. There were, however, a number of marine boilers available from destroyer escort vessels then being dismantled. The design of these boilers is such that they can only be operated satisfactorily on good water, and can only be fired by oil or gas fuel.

The fuel problem was of no consequence because of the availability of natural gas at Texas City as the normal boiler fuel. The water supply problem was entirely different because the plant had operated with a high percentage of well water make-up containing total solids in the neighborhood of 1500 parts per million. But further study developed a method by which all of the condensate returned from the plant processes could be segragated and supplied to the new boilers. A battery of rehabilitated oil field boilers was retained to carry the balance of the steam load on 100 per cent make-up of the treated well water.

Fuel and water problems solved, these marine type boilers became the most attractive of the second-hand boilers available. The next problem, and one of no lesser magnitude, was that of dismantling, shipping and re-erecting these boilers.

From the sites at which the destroyer escort vessels were being dismantled, shipment of the boilers in their normal upright position could not be made because of railroad clearances. It was found that they could be laid on their sides and shipped over a long and devious route by greasing bridge and tunnel clearances. But this meant practically dismantling and re-erecting the boilers, and would have required serious modification or procurement of new tubes—each containing 792 one inch tubes and 136 one and one half inch tubes. Obviously, either method would have consumed too much time.

In addition to the boilers being removed from the destroyer escort vessels, several of the same type which had been used as a temporary measure in the early days of the Manhattan Project were available as surplus at Oak Ridge, Tennessee. The shipping problem from this site was less serious because it was found that they could be transported the entire distance by barge.

Fortunately, the boilers were installed near the Clinch River. By loading them onto barges, and with the help of the TVA, they could be towed into the Tennessee River, down the great loop to the Ohio. From there it was a normal barge run down the Mississippi and around to Monsanto's dock at Texas City. But first there was the problem of securing the boilers in such a manner that a minimum amount of repair would be required at the destination.

This was accomplished by designing and fabricating a simple structural steel cradle composed of standard structural shapes and arranged to receive the anchor bolts by which the units were normally secured to their foundations. Accordingly, these cradles were fabricated at the point of removal. With the boilers carefully jacked off of their foundations, the cradles were slid under them, and the boilers jacked down and bolted to them. All crane movements were made by attaching the crane hooks to the cradles only.

On arrival at Texas City, handling from the barge to a lowboy trailer and on to the permanent foundation was accomplished in the same manner. The final operation was to jack them off of the cradles, remove the cradles, and lower the boilers onto their foundations. It was gratifying to find after they were secured that it was not necessary to re-roll a single tube in five of the units, and only a few tubes in the sixth. No damage had been done to any of the refractories in any of the units throughout the entire operation.

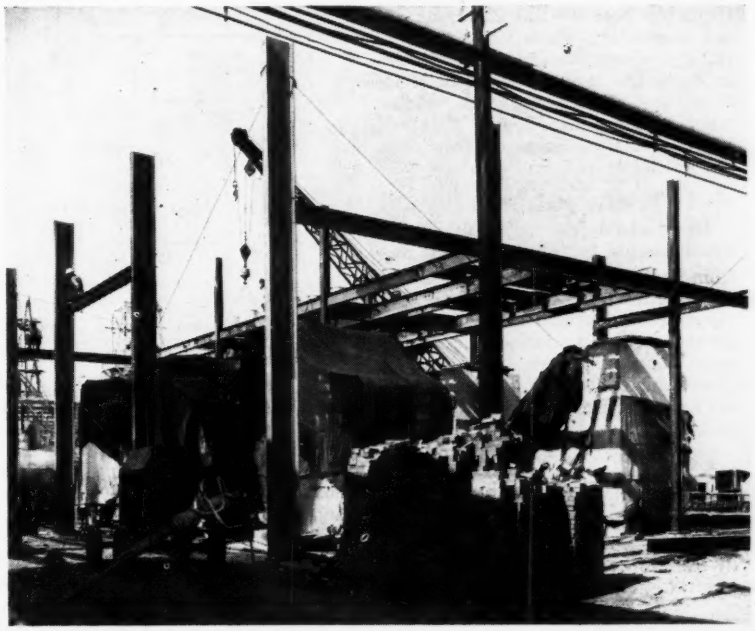


Fig. 1. This photograph shows the last of the boilers being lowered onto its prepared foundation. The boilers were moved from the barge to the plant site on lowboy trailers

Simplifying Boiler Design by Eliminating Enshrouded Mystery

A common-sense view of boiler design by an engineer who has spent nearly all his life in boiler design work . . . Basic principles . . . Furnace design . . . Effect of heat absorbing surfaces on combustion . . . Heat liberation for different type furnaces . . . Factors affecting circulation . . . The Champagne glass vs pop bottle principle of boiler design . . . Use of oxygen in boiler furnaces . . . Once through boilers and use of positive pressure combustion . . . Steam cycles using heat transformers

By L. J. WESTIN*

THERE has been a tendency on the part of many in the engineering profession to look upon the field of boiler design with a feeling of awe; to assume that present designs cannot be improved greatly. This probably is due, partly, to the high operating pressures used and to the apparent complexity resulting from too many different designs. Yet, if one looks at boiler design sensibly it will be found that the boiler field provides as much opportunity as any other field for improvement and development. John Phillips Badenhausen once said, "No matter what kind of a boiler design is thought out, some damn fool will buy it." This, certainly, seems to have been true. Instead of striving for simplicity the opposite seems to have guided the efforts of boiler designers. The more complicated and mysterious the design, the easier they were to sell. Why? Probably because the customer did not understand the art and, maybe, the manufacturers did not want him to know too much as it might show them up. Furthermore, no matter what was purchased and installed, it would make steam; but so will a tea kettle!

Basic Principles

There are a few simple principles which should be followed in the design of any boiler. These are:

1. Preheat the feedwater up to very nearly saturated liquid temperature. This is done by means of open deaerating feedwater heaters, closed stage heaters and economizers or boiler preheaters (forced circulation), which term I prefer.

2. Add the latent heat to the water fed to the boiler to change it from a liquid to a vapor, (heat of vaporization). This is accomplished by convection and radiant surface in the water-walls and boiler heat absorbing surface, or a combination of both, either by natural or forced circulation.

3. Superheat the generated steam vapor to the temperature desired, by either convection or radiant heat absorbing surface or a combination of both.

Furnace Design

The primary consideration in the design of any steam generator is the furnace! The first thing we must have is a proper furnace for burning the fuel, whatever it may be, to give the best combustion efficiency. Up until recent years this most important principle was passed by or overlooked, possibly due to ignorance. Instead of putting the heat where it was usable, logically close to the heat absorbing surface, just the opposite was done. The fuel was burned in refractory Dutch ovens away from the heat absorbing surfaces and then after the resultant gases had cooled somewhat by radiation loss through the refractory, the gases were directed to the heat absorbing boiler surface. Today, in most good designs we put just as much heat absorbing surface in the furnace as possible, in the form of so-called water walls (radiant heat absorbing medium). This is logical, because per square foot of heat absorbing surface we generate 3 or 4 times as much steam in radiant water wall surface as we do in the convection heat absorbing surface. However, as furnace sizes go up the ratio of wall area to furnace volume goes down; that is it may be advisable, in the near future, to consider the use of *shadow* water walls within the furnace proper.

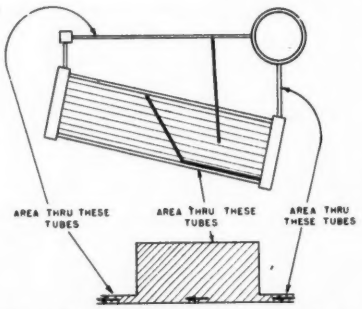


Fig. 1 Flow diagram showing circulation through a cross-drum, straight-tube boiler

After we have the furnace designed with as much radiant heat absorbing surface as possible, and laid out to effect the best combustion with the least amount of excess air, to make use of the radiant heat absorption principle of Stefan Bolzman's law, that the rate of radiant heat transfer varies as the 4th power of the absolute temperature, we can go on to the balance of the heat absorbing medium. However, regarding the furnace, it is well to consider the use of the hottest possible air for combustion to effect the highest possible furnace temperature to make use of radiant heat transfer and give good combustion. In the combustion process; of necessity, the air and fuel as burned must eventually reach the gas temperature in the furnace; therefore, the hottest possible combustion air more quickly effects the combining of our heat producing elements (generally carbon and hydrogen, present in the fuel, and oxygen, present in the air). Preheated air also increases the temperature in the furnace thereby increasing the radiant heat transfer for higher heat absorption and efficiency.

Heat Liberation

Next, with respect to combustion, it is well to consider the heat liberation per cu ft of furnace volume. This should be as high as possible to give the highest possible furnace temperature, which is directly dependent on the fuel to be burned, to obtain the highest radiant heat transfer. If the fuel is more or less pure, with no slagging component, ash, the heat liberation per cu ft can be very high, up to hundreds of thousands of Btus per hour, per cu ft of volume, and possibly millions of Btus per hour, per cu ft of

*Mr. Westin who was formerly Vice-president of John Phillips Badenhausen is now with American Engineering Company

volume—and let's hope that in the not too distant future we can also find ways to handle the ash with extremely high heat liberation per cu ft of furnace volume. There is some very interesting experimental work being done by some of the combustion and boiler and gas turbine research organizations in this respect now. Generally speaking, for bituminous coal having an ash melting point from 2100 to 2600 F the heat liberation per cu ft of furnace volume with water wall dry bottom furnaces is held between 20,000 to 30,000 Btu per cu ft at full load with pulverized coal and spreader stokers, and for underfeed and overfeed traveling grate stokers between 40,000 to 60,000 Btu per cu ft. For small sizes of anthracite coal, Nos. 3 and 4 buckwheat (steam sizes) the furnace volume with traveling grate stokers should be sized to give between 20,000 to 30,000 Btu per cu ft at full load, which is dependent to a large extent on the size of the steam generator. This results in a sufficient slow gas velocity in the furnace to limit the carryover of unburned fines to a reasonable level. For oil and clean natural gas, with stationary designs it varies from 18,000 to 60,000 Btu per cu ft dependent on steam generator size and conditions of installation. In Navy practice, at peak loads, with good grades of oil heat releases go up to 300,000 to 400,000 Btu per cu ft of furnace volume and even higher heat releases have been considered.

Now, regarding the balance of the steam generating unit, let's first consider a natural circulation unit. It should never be necessary to use more than one drum, and that the main steam and water drum. The only deviation would be to have another submerged, or so called "mud drum" to provide a connection for the boiler heat absorbing surface. Large volumes of water in the lower part of a boiler are detrimental to good design for this large volume of water will expand and contract with variations in steam pressures of only several pounds, and it is almost impossible to hold an absolutely steady steam pressure. As the pressure goes down, the stored, or latent, energy in the water releases steam bubbles or vapor, which creates added turbulence or swell. This expansion and contraction will vary the water level in the main steam and water drum and tend toward priming on violent swings in load. This is minimized if the volume of water below the main steam and water drum is kept as small as possible.

If a lower drum is used the active water volume can be limited. Proper design could be attained by the use of an internal circumferential baffle limiting the active water to a layer, say, 1½ to 2 in. thick. The design might involve an inverted cone with the weight of water diminishing in the direction of the apex. The opposite would be a pop bottle, having a small neck at the top and a large volume below. When a bottle of warm pop is opened there is violent foaming and most of the liquid is lost. The entrained steam in the water of a boiler can be compared to the CO_2 stored in the soda pop.

Champagne Glass Theory of Design

A boiler should be designed more on the order of a champagne glass. A good champagne glass has a hollow stem opening into a wide flare receptacle at the top. The large area at the top easily liberates the gas formed in the stem and in the lower portion of the cone shaped glass, hence there is no excessive turbulence.

If most of the water in a boiler is stored in the lower part a decrease in volume will immediately bare the heat absorbing surfaces at the top and it becomes necessary to cease firing to prevent the upper parts of the tubes from overheating.

It should be evident, therefore, that large water storage volume at the lower part of a boiler is detrimental both from an operating standpoint and for safety. Present day large water tube boilers when operating at full capacity, have safe water storage for only a matter of seconds.

It is well at this point to call attention to the old straight tube cross-drum boilers. These designs were good performers as far as holding even water level, thereby minimizing priming and foaming. They utilized only one upper drum and the circulating system tended to con-

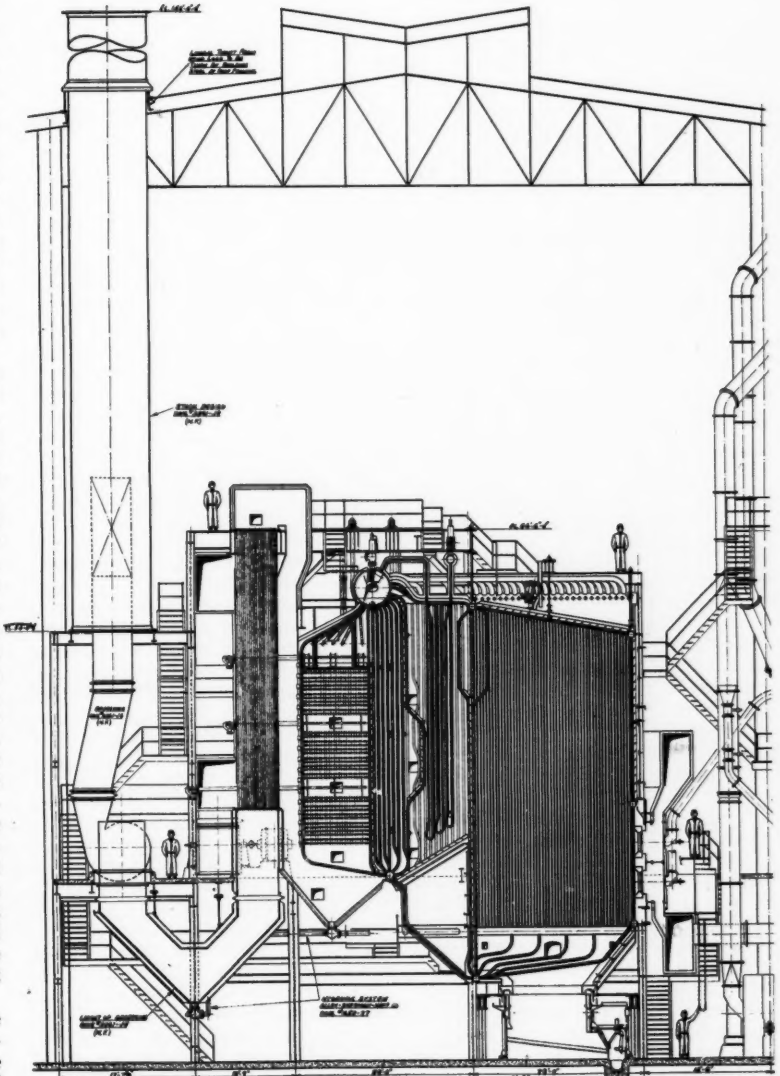


Fig. 2 The single-drum design is readily adaptable to various arrangements of superheaters, economizers, etc.

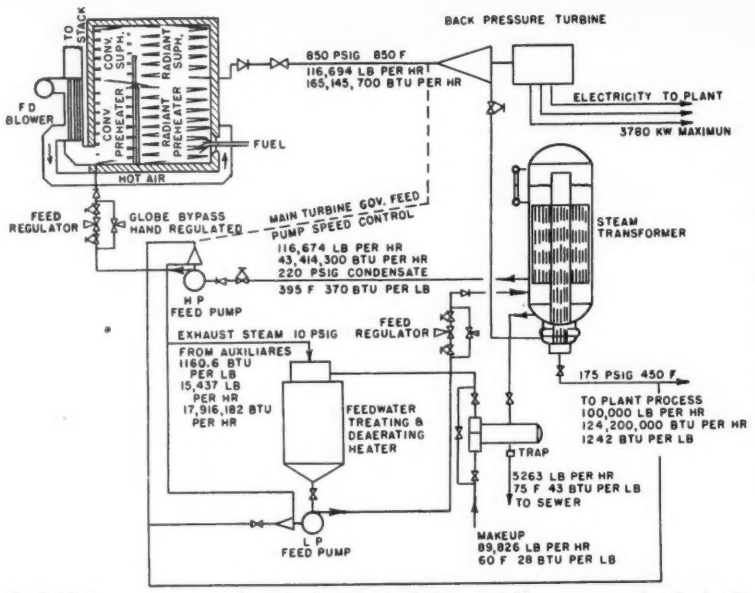


Fig 3 High pressure, once-through, forced circulation, variable pressure, closed circuit cycle

verge to an apex at the bottom. Their principle deficiency, however, was a restriction in the return circulation path—the nipples at the top of the return headers, thence to a common header and then to the connecting overcomer tubes to the main drum above the water level. This is better shown by Fig. 1. Because of this design the top tubes in the bank at high loads developed stagnant circulation resulting in considerable tube failures in these *top tubes* and not the bottom tubes which were exposed to radiant heat in the hottest zone. It was found by experience, approximately, that if the tube bank was lmiited to 7 tubes high, giving a ratio of 1 feeder to 7 generating tubes, no trouble developed.

With regard to the number of drums, two or more upper steam and water drums are not required because eventually, by the use of reliever tubes, all the steam—every ounce generated—and all the water circulated must go to the central or main steam and water drum to complete the circulation. In reality, all multiple drums do, is to give false steam storage space which is not very effective. On the other hand, I agree, and will not argue, that the larger the one main steam and water drum is the better within reasonable limits for natural circulation units. Usually, forward, upper, multiple drums, if on the same level as the main rear drum, become filled with water at high ratings because water, if it is to circulate, must go either from a high to a lower level or from a place of high pressure to one of low pressure.

Boiler designs incorporating boiler preheaters, or economizers, are readily adaptable to single drum boiler units designed with headers for the lower vessels. A sketch of this type of unit is shown in Fig. 2. Note that the water preheater discharges below the normal water level in the main steam and water drum. The discharge is as close to the bottom of this drum as possible. This establishes the good feature of always having the preheater flooded so that with decreases in load when no water is passing through or at low loads with slow circulation, no detrimental effects, water hammer or steam binding, develops. There is always some induced circulation. Even if the preheater tends to steam it is not harmful. The reaction is similar to submerging a bottle in water—it fills up. In a specific instance through an oversight in trying to get a new boiler unit of this design on the line quickly, the boiler operated for several days, by-passing the water preheater, by feeding direct to the main boiler circulation path, with no detrimental effects. None of the tubes were overheated or loosened up. This was determined by taking the unit off the line and giving it a hydrostatic test of 150 per cent of design pressure.

Once-Through Boilers

I have never understood why we in this country, for condensing applications where not much make-up is required, have never gone to "once through" forced circulation boilers. And, hand in hand with this, could go variable pressure units having the turbine governor regulate boiler pressure so that we would attain practically constant steam volume for any load range using full steam admission to the first rows of turbine blades, which would give the maximum efficiency over complete load ranges with no throttling governors — eliminating nozzle blocks and partial admittance throttling. This type of boiler is the simplest of all designs. Water is pumped in at one end and steam issues from the other end. All they consist of is continuous tubes in the heat area made possible by designs utilizing only tubes and headers. All drums can be eliminated. The rate of firing will be dependent on the final steam temperature maintained; this can be controlled either automatically by temperature control or manually. The steam pressure is dependent on feedwater pressure going into the unit plus the rise due to volume increase when changing from liquid to vapor.

Now let us look at how much heat absorbing surface is necessary for good results. This will be presented on a "rule of thumb" basis, obtained from experience on natural circulation designs. A quick check is pos-

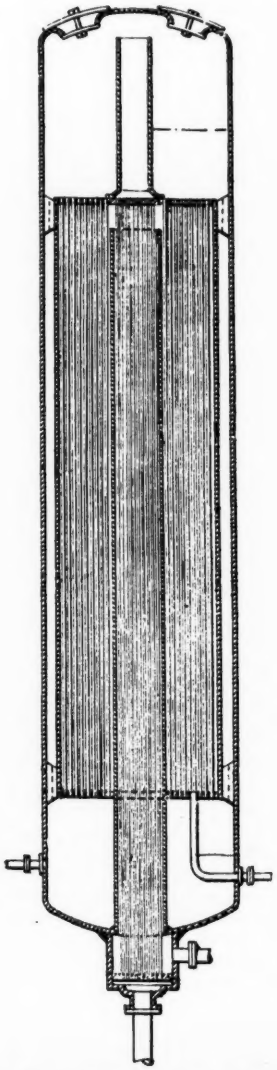


Fig. 4 Details of the J. P. Badenhausen Steam Transformer

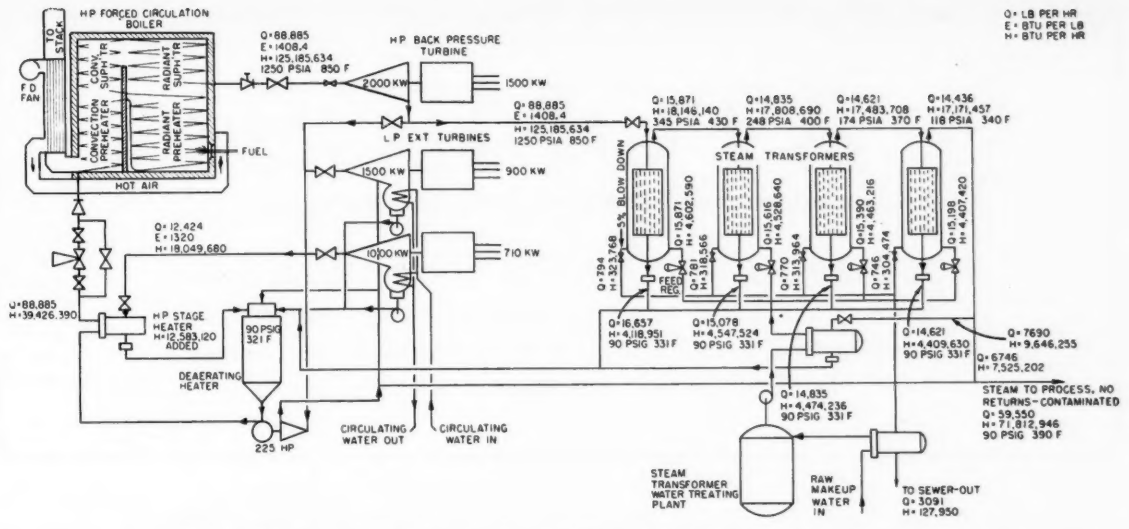


Fig. 5 High pressure topping cycle with all evaporated feedwater for high pressure circuit

sible by using the following: 7 to 9 lb of steam per hr from each square foot of convection boiler surface; 4 to 5 lb of steam per hr from each square foot of economizer or preheater surface; 25 lb of steam per hr from each square foot of radiant water wall surface based on circumferential area, or 75 lb of steam per hr from each square foot of water wall surface based on projected area; and 6 lb of steam per hr for each square foot of convection superheater area, or 20 lb of steam per hr for each square foot of radiant superheater heat absorbing area. These figures will give the continuous rating in lb of steam per hr. For short time peaks ratings, increase by 10-15 per cent.

Another rule of thumb that has been developed which is helpful to most engineers for figuring fans is: Forced draft fans — lb of steam per hr $\times$ 0.33 = cfm of air at 90 F. Induced draft fans — lb of steam per hr $\times$ 0.6 = cfm of gas at 400 F. These are based on 84 per cent efficiency, 25 per cent excess air and 1100 Btu heat added per lb of steam using 17 per cent tolerance for FD fans and 22 per cent tolerance for ID fans. If the conditions vary from these figures, it is very easy to proportion the change; i.e., add 1 per cent for each per cent lower than 84 per cent efficiency and vice versa —for other heat addative conditions, say 1050 Btu per lb multiply by 1050/1100 and vice versa.

Another good helpful formula is: Fan hp = cfm $\times$ 0.000157 $\times$ static pressure in inches per fan efficiency. Most fan efficiencies range between 50 to 70 per cent, 60 per cent is a good average. Also, for figuring duct or breeching areas, take the cfm and divide by 3500 ft per min velocity, which gives the approximate duct area in square feet.

I believe that in the near future the stationary boiler art will begin to adopt the use of positive pressure combustion furnaces—and it will be a step in the right direction. For with pressure furnaces a higher density gas results, giving better heat transfer and better combustion. This of course is not new having been used in marine boiler practice for a long time. It will effect better economy because as now with both forced and induced draft fans, the hp requirements are high as the induced draft fan handles high temperature gases which means high volumes. And, of course, volume is the determining factor in fan horsepower as the volume varies directly as the absolute gas temperature. It is much more economical to raise the cold air required for combustion to a higher static pressure and force the products of combustion through the furnace, boiler passes, gas uptake breeching and to the stack. This would be particularly adaptable to oil, gas, pulverized coal, and spreader stoker firing. It also gives much more desirable combustion results as positive pressure assures a heat soaking effect to all parts of the steam generating unit and no air infiltration, thus giving the same CO_2 at the exit as in the furnace. If there is any fear of furnace pressure forcing the combustion gases out of furnace leaks, the furnace can be built with the incoming air plenum chamber around it—a casing within a casing. This will be desirable as it will result in an insulating medium between the refractory and outer casing. Considerable yearly operating economy can be affected by reducing fan or blower hp and simplicity as there is only one set of fans required instead of two.

Oxygen For Combustion

At this point it is also well to bring out the coming use, in the not too distant future I hope, of using pure oxygen for combustion in boiler furnaces. Through recent developments, brought on by the war, for producing cheap oxygen, the cast is almost low enough to use oxygen for boiler furnace combustion. It is easily understandable what pure oxygen for boiler furnace combustion will mean. As at present using air for combustion 4/5 (approximately) of the air used for combustion is inert unusable uneconomical gas mostly nitrogen which is a definite waste as this inert gas must be heated by combustion temperature and passed through the unit. Not only do the gas passes have to be made sufficiently large enough to pass this inert gas but also the fans have to handle this wasteful 4/5 element, i.e., the fan hp could be cut 4/5s. Also with pure oxygen, furnace temperatures could be raised terrifically high making mandatory a completely black surface or total water cooled furnace, and we could approach almost perfect combustion. Any type of fuel could be burned with the ultimate in combustion efficiency with ease of control and extremely wide load ranges. Boiler and furnace sizes would decrease in size and high mass velocities for the ultimate in heat transfer could be used. Heat liberation in Btu per cu ft per hr could go to unheard of values, millions of Btu per cu ft per hr could be commonplace. The ash component of the fuel would probably be consumed as fuel and would no longer be a problem as any material if raised to a high enough temperature in the presence of pure oxygen will burn.

We should increase the experimental and development work to strive for cheap means of producing pure oxygen (O_2). Probably the answer may be separation of oxygen from air by centrifugal force as the

(Continued on page 122)

ATOMICS

A New Section added to POWER GENERATION to cover current and forthcoming developments in atomic energy and related developments and applications in Nuclear Physics

NUCLEAR POWER FOR MOBILE USE

Because of the interest of the military in the application of nuclear energy it is quite possible that we may have nuclear power plants for mobile use before we have them for stationary service. Signing of a contract between Westinghouse and the Atomic Energy Commission may accelerate the development of nuclear power plants for marine propulsion

By **ANDREW W. KRAMER**, Editor, Power Generation

THE RECENT ANNOUNCEMENT that Westinghouse had signed a contract with the Chicago Operations Office of the U. S. Atomic Energy Commission for the construction of an experimental nuclear reactor to meet specifications for eventual use for ship propulsion reflects the difference in interest and attitude in atomic energy between the military on the one hand and private power interests on the other.

The military has no commercial irons in the fire, no vested interests to protect. It knows what atomic energy is capable of from a weapon standpoint, as does everybody else, but the military also has faith in atomic energy as a source of power for its mobile units in the air and in the sea. The Navy is interested in having power plants in ships that would give them practically unlimited range and the air forces, naturally, are interested in the same thing. Both branches of the military realize that a fuel with a heating value of almost 40 billion Btu per pound has attractive possibilities in making possible such power plants regardless of the difficulties which may lie in the way of their development.

In view of the fact that we already have B-36's with a bombing range of some 10,000 miles one might wonder why the air forces are so concerned about atomic power for aircraft propulsion. Figure 1 explains this as well as anything else. These curves show how the range of an airplane varies with its weight and speed. As the speed increases the range decreases very rapidly, so rapidly in fact that a supersonic plane such as the X-1 runs out of fuel in a matter of minutes. An atomic powered airplane would be represented by a horizontal line on Fig. 1.

Under its NEPA (Nuclear Energy for the Propulsion of Aircraft) program at Oak Ridge, Tennessee, Fairchild Engine and Airplane Corp. has done considerable investigation and research in the development of atomic power plants for aircraft and it is not unlikely that before many years have passed that we will actually have atomic powered planes.

This may seem optimistic in view of the fact that when atomic energy first came into the limelight with the dropping of the bombs on Hiroshima and Nagasaki, the possibility of atomic powered planes were more or less ruled out because of the radiation danger. It was pointed out, then, that the shielding necessary to protect personnel aboard an atomic powered plane would be so heavy as to defeat the idea.

The Shielding Problem in Aircraft Plants

This, of course, is still true; nothing in the more recent development of nuclear physics has lessened the danger to personnel from radiation. In the meantime, however, our idea of large planes has grown and it may be possible that our very largest planes can be made to carry enough shielding to protect personnel. More important however, than recent developments in the size of airplanes is progress in the design and operation of unmanned aircraft, ie, the use of Robot planes or planes of the guided missile type. In war, such aircraft would be expendable and they could be equipped with atomic power plants that had no shielding whatever. Using enriched "piles" as atomic reactors such power plants could be made reasonably light and the planes would have practically unlimited range. The possibility of building atomic powered planes of the unmanned type is perhaps the principal reason for the intense concern of the air forces with the development of atomic power.

Curiously enough, it is quite possible that an atomic power propulsion plant for an airplane will be simpler than an atomic power plant for stationary service, first because of the absence of heavy shielding and secondly, because of the jet principle of propulsion.

The simplest type of atomic power plant conceivable would be an air cooled nuclear reactor installed in the passage of a ram jet as shown in Fig. 2. Air forced through the cooling passages of the reactor as a consequence of the plane's forward velocity would be heated to a high temperature and the reaction of the expanding gases from the jet nozzle would drive the plane forward. Since such an arrangement would involve no moving parts and since the cooling medium would not be re-circulated, the engine could be designed to operate at an extremely high temperature. The pressures involved also would be relatively low and it might be possible to use ceramic material capable of withstanding extremely high temperature without destruction.

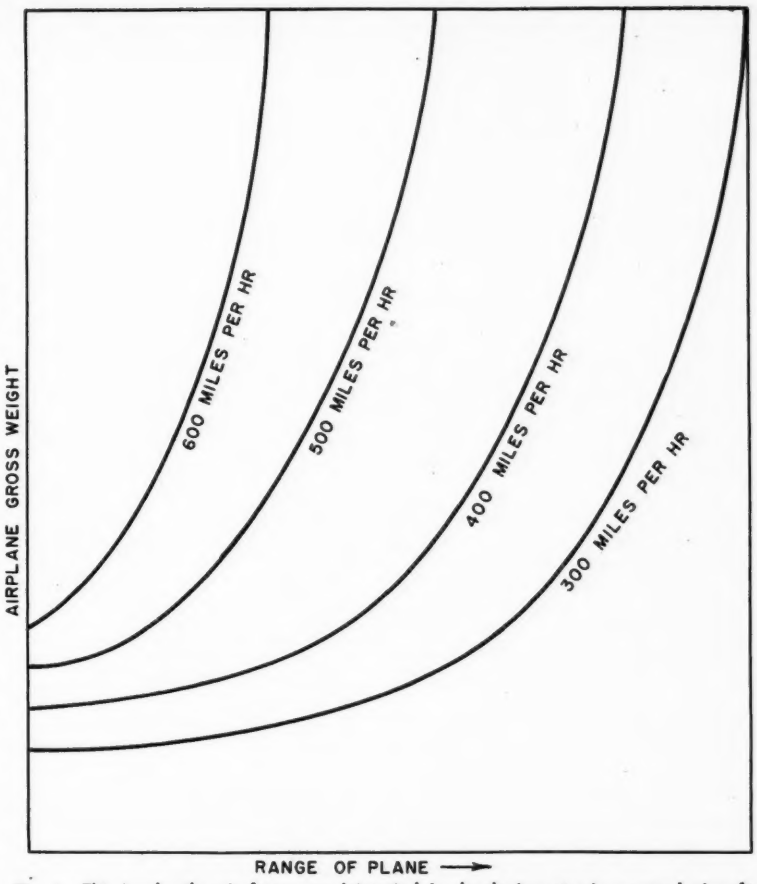


Fig. 1. This is why the air forces are interested in developing atomic powered aircraft. An atomic powered plane would be represented by a horizontal line on this chart

Type of Aircraft Nuclear Power Plants

In a report by Andrew Kalitinsky, Chief Engineer of NEPA project, last summer,[1] four possible types of atomic power plants were briefly described. One of them was the ram-jet type of plant shown in Fig. 2. The other three types are shown in Figs. 3, 4 and 5 respectively.

Figure 3, it will be noted consists of a nuclear reactor acting as a boiler and delivering steam or perhaps some other vapor to a turbine. After passing through the turbine, the vapor is condensed in an air condenser and the fluid delivered back to the reactor. This, it is obvious is simply a steam turbine driven propeller fed from a nuclear reactor.

While it may be possible to develop a drive such as is shown in Fig. 3, it is more likely that, for aircraft drive, use will be made of a gas turbine. A gas turbine type of aircraft power plant is shown in Fig. 4. This plan incorporates the turbo-jet idea. Air entering the compressor is compressed and then delivered to the nuclear reactor where it is raised to a high temperature. This high pressure, high temperature air is then delivered to the gas turbine driving the air compressor and the exhaust gas from the turbine used in a jet. Such a jet could be used in combination with a propeller drive by simply extending the compressor shaft forward so as to carry a propeller.

Neither of the three types of plants shown in Figs. 2, 3 and 4 would be useful in a "space" type missile since all of them depend upon the presence of an atmosphere. For use in a rocket a different arrangement would be necessary. Figure 5, for example, shows the application of

[1] Aero Digest, Aug. 1948, page 58.

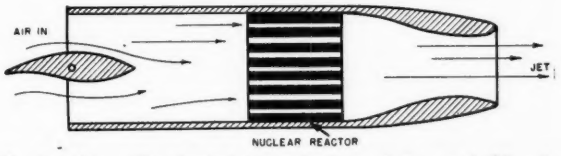


Fig. 2. Above: The simplest type of power plant conceivable. A ram jet type engine using a nuclear reactor to heat the hair

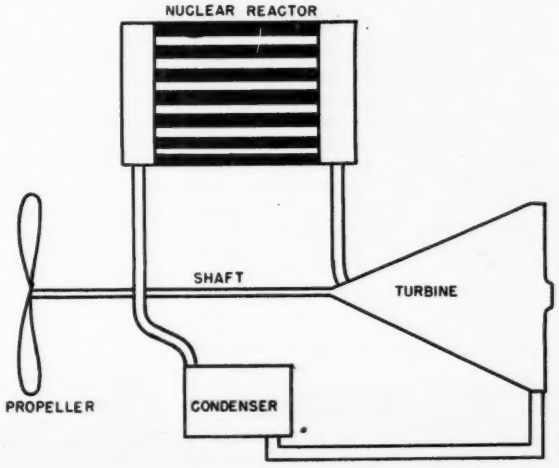


Fig. 3. A propeller type power plant using a nuclear reactor boiler in combination with a turbine

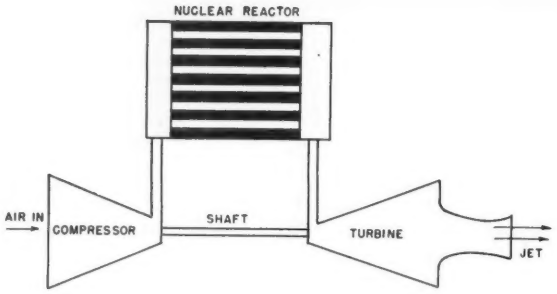


Fig. 4. A gas turbine type of nuclear power plant designed on the turbojet principle

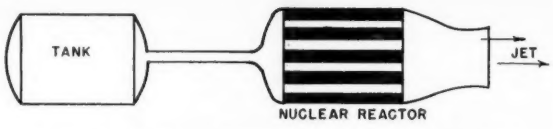


Fig. 5. Showing the application of nuclear energy to a rocket

nuclear energy to a rocket. Here, a gas or liquid is stored under pressure in tanks and this is heated or vaporized in passing through the nuclear reactor. The resulting expansion of the gases issuing as a jet would drive the missile forward.

All of these power plants, it will be seen, are *thermal* plants; that is, they involve the generation of heat in a controlled nuclear reactor. This is the only type of nuclear power plant that is possible with our present knowledge. At various times there has been speculation regarding the possibility of converting nuclear energy directly into electrical energy but as had been indicated in other articles in this section[2] there is little likelihood of this ever happening. Nuclear fission is basically a thermal phenomenon—it is *random* energy and until random energy can be *organized* it *is* thermal energy. It is similar to the thermal energy in a boiler furnace. The molecules of the gases in a furnace are in continual motion, colliding with each other and with the walls of the furnace. This is *random* or unorganized energy. To organize this random energy it is necessary to transform the haphazard motion of the molecules into motion that is essentially in one direction. This, in the case of a furnace can be accomplished by means of a steam boiler which first converts the random kinetic energy of the furnace gases into random kinetic energy of the steam and then, by virtue of the outlet leading to a region of lower pressure a directional quality in the motion of the molescules is attained.

There is, thus, about as much chance of converting nuclear energy directly into electrical energy as there is of converting the heat energy of a coal or oil fired furnace directly into electrical energy.

The Shielding Problem

The same general principles underlying the design of a nuclear power plant for aircraft also apply to the design of such a plant for marine propulsion, except that in the case of the latter, the shielding problem offers less difficulty. A ship, naturally, is massive and easily capable of carrying the heavy shielding that is necessary for a nuclear reactor. In the case of aircraft plants, considerable attention has been given the use of neutron reflectors. A good reflector may turn back as many as 90 per cent of the neutrons escaping from a reactor. While such reflectors would be much thinner than neutron absorbing type of shields, it would be very wrong to assume that the use of neutron shields would solve 50 per cent of the neutron shielding problem. It is more likely to represent only about 10 per cent of the job of reducing neutron escape to a tolerable level. By the same token it is very important to prevent the escape of seemingly small amounts of radiation through joints or seals in the shields. One may be tempted to consider a leakage of 1 per cent as negligible when in reality this 1 per cent might be more than a million times enough to kill an individual.

In announcing the contract between Westinghouse and the Atomic Energy Commission, the object was stated to be "the production of a nuclear power plant which may be adapted to the propulsion of a naval vessel within the *shortest practicable time.*" The stress on the time element is encouraging and the development is one that should be regarded with the greatest interest by all who are concerned with the production of power.

[2] Nuclear Energy and Electric Power, Part I, Power Plant Engineering, March 1947, page 104 and Part II, May, 1947, page 101.

ATOMICS

UP AN' ATOM

By RATIO

THE WRITER has noted that among engineers who gather for various purposes there is usually one subject which sifts to the surface at some stage in proceedings and takes precedence over other immediate matters. Authorities seem agreed for once that somewhere in the not too distant future there looms a real threat in prospective scarcity regarding our sources of energy, particularly known quantities of coal and oil fuel so far as can now be estimated. It is stated that in U.S. and Canada electrical consumption has doubled in the past seven years. This is quite understandable to a man on the street and can be assumed correct.

We could naturally expect such an increase of demand in wartime production of material and munitions regardless of cost. We could further expect that demand to lessen considerably after the war but contrariwise instead of receding from all time high it goes right on to all time higher! And my eyes can see the coming of no imminent let up. Thousands upon thousands of horsepower steam plants have been installed, reputedly operating to capacity, further thousands in old equipment are in action which really should be scrapped, except that new units are not available fast enough. Corporations with a big backlog of undistributed earnings are plowing these back into production as capital installation which doesn't pay income tax. So long as all these manufactured goods can be used by eastern countries and paid for by Canada and U.S. Aid funds there won't be much slackening off in demand, even with a change from sellers to buyers market, in domestic consumption.

Any man on the street with a little thought can visualize rapid constantly increasing use of electricity on this continent at least, more especially in rural districts where manpower has gone to town for the time being. Where it is available electric current is so much safer, cheaper and convenient to use that the only wonder is why older-fashioned apparatus survives. In Ontario with provincially owned Hydro, a horsepower hour costs less than half a cent, (three cents for first rated number of kilowatt hours monthly, one and a half cents for second allotment, and one-to-two thirds of a cent for all over that). Seven hundred and forty-six watts equal one horse power, so the grammar books say, and there you are! Any engine which will deliver energy right on the exact spot where it is needed for less than a cent per horse power per hour at only the turning of a button takes the cake without competition. John Q. Public is going to insist emphatically that we engineer boys produce it for him if at all feasible. But

you've got to give us the raw material, which to date, consists of coal or oil or waterfall, and these three presently known parents of energy must be delivered to the area of power demand. Granted this and we'll produce all right.

Nature has played a mean trick in spreading coal and oil and falling H_2O round places without any regard to density of population and hasn't provided transmission or transportation. Witness the Big and Little Inch pipelines from Texas to Chicago. Watch Canadian railways hauling farm products from the west in such quantity that cars can't be spared for haulage of coal from Alberta where it is reported waiting in great gobs for hungry eastern markets. Two thousand miles is a long wheel on rails and hardly to be undertaken unless economically sound. Delivered price set off against delivered cost will be the criterion, and some, at least, of our presently worked coal mines near to populous centers are reputedly nearing depletion, and we are told that 50 years even at today's rate of consumption will see them exhausted. In this game whoso doesn't look years ahead is quite liable to be caught with his stepins lowered.

High tension electrical transmission is not feasible to greater distances than 250 miles we're told, because of heavy losses in transit, though some think it possible to develop much higher voltage than now carried and deliver with a nearer ratio to actual production. Shoot a little more pressure through the lines assuming that a greater percentage arrives at its destination and write off atmospheric losses, and leakage through insulators and at transformer stations, a lot seems to disappear somewhere enroute.

Waterpower exists in huge quantities in weird outlying places but no national hero has yet brought forward means to bring it hither. Hence the midnight oil and head-scratching by our scientific friends.

Research by industry and governments goes forward apace particularly with reference to atomic possibilities, though all are a little leery about picking the darned thing apart. It's like looking for honey in a black hornet's nest. The unbelievable energy and potential wholesale destruction latent in that atom has 'em all scared, and no wonder. Just split it the wrong way, add one wrong electron or a few other possible playful experiments and one could explode our whole atmosphere in a flash, in three breaths no living being would exist. Superman, moth and mollusk all gone! Did you see pictures of the Bikini tests? If you have a good strong heart go ahead and give a look. Films are shown taken from robot planes at various altitudes and distances from the actual Bikini bombing, these planes, remotely controlled, approached the scene much nearer than any human being dared to and took closeup photos of that mighty upheaval. A stupendous mountain of water, half a mile in diameter and height, billions of horsepower as we know it, hoisted "from earth to heaven" by about two pounds of actual energy producing explosive! A good thing the Pacific isn't a narrow pond. Ships and material at quite some distances from bombing site are still dangerously radioactive, some I believe have since been sunk as a potential menace.

No one apparently knows yet what uranium can do, or what it might do if the stupendous forces therein contained were turned loose. U235 and U238 they think are much too dangerous and touchy (or non touchable rather) for purposes of power production. I saw a half dollar which had been exposed to the rays some time previously and which would cause a Geiger counter to turn hand springs if brought near it. Any apparatus for subtracting energy from these U babies would have to be shielded from humans by many thick feet of lead or concrete, any atomic power producing station even of modest proportions would instantly assume multi-million dollar class. It would perforce have to operate throughout its lifetime without a human being approaching it, no handling, repair or adjustment, . no replacement of element or parts, because it is and will remain radioactive to a fatal degree so far as is known. It is possible that there are actual miinature plants now producing in a tiny way but we're not informed as to results. We are pretty sure the potential is there all right if it can be handled. Granted successful safe atomic fission and we can have unlimited power without using up and thereby destroying for all time our fuel and power stocks as we now know them.

Maybe someone will find next week or next year how to combine a different electron or add a neutron or moron some place along the research line which will make up U240 or U two hundred safety first or something more docile than anything to date. I've read of a man on the hoof required to walk ahead of the first railway engine during its whole journey to warn people of the dangerous thing. Bet a nickel the first guy who discovered gunpowder thought he'd split the atom too, and now we use these awful things without a second thought. Some scientists are confident that power from atomic fission is just waiting around the corner, then goodby to coal and clinkers, oleo and odors, work and worry, maybe. With fingers crossed we will waddle along and wish 'em the best of luck. But we'll keep a good respectable distance—"I don't want her, you can have'er, she's too hot for me!"

ATOMICS

WESTINGHOUSE TO DEVELOP NUCLEAR REACTOR FOR SHIP PROPULSION

THE CHICAGO OPERATIONS Office of the U. S. Atomic Energy Commission has announced that a letter contract has been entered into with the Westinghouse Electric Corporation of Pittsburgh, Pennsylvania, for the construction of an experimental nuclear reactor to meet specifications for eventual use for ship propulsion.

A. Tammaro, manager of AEC Operations in Chicago, announced that work under the contract will be carried on in cooperation with the Argonne National Laboratory, major center of the Commission's reactor development program. The objective of the developmental project is to meet requirements provided by the Navy Department Bureau of Ships for the propulsion of naval vessels.

The development of such specialized nuclear reactors was among the functions assigned to the Argonne National Laboratory in January, 1948, when this laboratory was made the major center of the AEC reactor development program. Under the terms of this allocation, the responsibility for the design, development and engineering of the new reactor rests with the Argonne Laboratory. Westinghouse has been delegated responsibility for the detailed engineering, construction and operation of the reactor, and will undertake such research and development activity as may be assigned to it by the Commission.

The Westinghouse Corporation has had extensive experience in atomic energy work, having made a substantial contribution to the war-time program of the Manhattan Engineer District in the processing of uranium and the manufacture of specialized equipment for use in the U-235 separation plant at Oak Ridge, Tennessee.

In announcing the contract, Mr. Tammaro said: "It is the objective of the Commission to produce a nuclear power plant which may be adapted to te propulsion of a naval vessel within the shortest practicable time. Our contract with Westinghouse will bring into the AEC program a company resourceful in engineering and construction know-how.

The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

BASIC POWER PLANT FIGURING—1

A Review for Old-Timers — A Must for Young-Timers

By WILLIAM H. ENGELMAN

No matter which you are, you must be able to do at least the basic calculations if you are to be a power engineer. If you have to study on your own hook, without benefit of college instruction, it's just that much harder. But as Donald Frederick pointed out in the June issue, all the fundamental information you need, or that you would study in a good school or engineering college, is all available to you even if you can't go to college.

All power engineers must know how to calculate pressures, temperatures, volumes, weights for steam, water and gases. They must know how to use tables of squares, cubes, square roots and so on; must know how to use the steam, air and gas tables; should have some practice in working with logarithms and the slide rule; should know how to figure steam and water velocities and pipe sizes; boiler efficiencies; turbine water rates; pump capacities; steam and water flows in single pipes and header systems; and so on.

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William H. Engelman, author of this series of articles, has had long experience in showing engineers and engineering students how to learn these things. He is a mechanical engineer in the Department of Public Utilities, City of Cleveland, Ohio engaged in the design, operation, and maintenance and testing of power stations, pumping plants and heating plants. In addition, he is in charge of the Steam Power Plant Engineering Course of 36 weeks at 4 hr per week, conducted jointly in Cleveland by The International Union of Operating Engineers, the U. S. Department of Labor (Apprenticeship Section), The Ohio State Board of Education and the Cleveland Board of Education. Any person employed in a power plant or in refrigeration, heating, air conditioning and allied fields is eligible to attend these classes.

In this series of articles, Mr. Engelman will present each month a portion of the data sheets he has prepared for the students in his Cleveland courses. Most of them are self-explanatory and the calculations have been carefully checked by other engineers.

He recommends that in connection with them you refer to ***Elementary Steam Power Engineering,*** by Edgar MacNaughton, (published by John Wiley & Sons).

Steam properties are as given in ***Thermodynamic Properties of Steam,*** by Keenan and Keyes (John Wiley & Sons). Complete mathematical tables, logarithm tables, and fundamental engineering data are given in the ***Mechanical Engineers Handbook*** by Marks (McGraw-Hill Book Co.) and ***Mechanical Engineers Handbook*** by Kent (John Wiley & Sons) and in other standard engineering handbooks. If you have any trouble getting such books, write to the editors, who can arrange to supply them to you.

Let's begin, then, with relations between fundamental units. And in order to start somewhere, we must assume the reader knows ordinary arithmetic and the most elementary algebra of simple equations, which are covered in elementary mathematics text books.

Table I. Relations between atmospheric pressure, mercury column and head of water; also volume and weight of water

14.7 lb per sq in. atmospheric pressure—30 in. mercury—33.94 ft. water—407.3 in. water													
14.7	÷	30	=	0.491	.	hence 0.49 lb.	=	1 in.	Mercury column				
30	÷	14.7	=	2.04	;	hence 1.0 lb.	=	2.04 in.	Mercury column				
14.7	÷	33.94	=	0.433	;	hence 0.433 lb. pressure	=	1 ft water or 1 ft. head					
33.94	÷	14.7	=	2.31	;	hence 1.0 lb. pressure	=	2.31 ft water	=	2.31 ft. hd.			
14.7	÷	407.3	=	0.0361	;	hence 0.0361 lb. press.	=	1 in. water column					
407.3	÷	14.7	=	27.70	;	hence 1.0 lb. press.	=	27.7 in. water column					
One Cubic Foot of Water in Terms of Gallons, Pounds, and Cubic Inches.													
In commercial practice the average weight of water is taken as:													
One cubic foot of water = 62.4 lb.													
One gallon of water = 8.333 lb.													
One cubic foot of water = 7.48 gal.													
One cubic foot contains 1728 cu in.; 1 gal contains 231 cu in.													
1728	÷	231	=	7.4805;		hence 1 cu ft	=	7.48 gal.					
231	÷	1728	=	0.1337;		hence 1 gal	=	0.1337 cu ft.					
1 ÷ 62.4 = 0.016026, hence 1 lb weight = 0.016026 cu ft of water													
Note: The volume of 1 lb of water in cubic feet for any pressure and temperature is given in: ***Thermodynamic Properties of Steam*** by Keenan and Keyes, 1936 Edition, (John Wiley & Sons.) This will be referred to in these articles as the Steam Tables.													

The ordinary pressure gage reads the amount by which the total pressure exerted upon its mechanism exceeds the atmospheric pressure. This is called *GAGE PRESSURE* and is read in pounds per square in., psig.

ABSOLUTE PRESSURE is found by adding to the gage pressure the atmospheric pressure as read on a barometer. The barometer is in inches of mercury and this reading must be changed to lb per sq in. by

THE AUTHOR

William H. Engelman is mechanical engineer, Department of Public Utilities, Division of Water and Heat, City of Cleveland, Ohio and director of the Steam Power Plant Engineering course given in that city for operating power engineers.

At the age of 15, he began 4 years of apprenticeship in Germany in a general blacksmith and machine shop, then served 4 years more as a journeyman. During those 8 years he went to night school; this prepared him to enter the College of Mechanical Engineering at the Polytechnickum, Bremen, Germany, where he was graduated in 1910. Immediately after graduation he came to the United States, worked in various mechanical and structural jobs and has been with the City of Cleveland, Department of Public Utilities, since 1924. He is a member of the ASME and NSPE. His close relationship with operating personnel has convinced him that an adequate training program for power plant operators is essential, since the modern plant contains equipment, instruments and automatic devices that can be handled correctly only by a properly trained crew.

multiplying it by 0.491, since a column of mercury 1 in. high by 1 sq in. in cross section exerts a pressure of 0.491 lb.

If the barometer reading is not given, the atmospheric pressure may be assumed to be 14.7 psi; this, by international agreement, is taken as the normal atmospheric pressure at sea level and at 32 F.

In most engineering work, for brevity, we often use Hg, the chemical symbol for mercury and H_2O for water, thus: 28 in. Hg means 28 in. mercury.

ATMOSPHERIC PRESSURE varies with elevation above or below sea level, and varies also from hour to hour at a given location, being affected by wind and weather conditions. The actual instantaneous value of atmospheric pressure may be determined from an accurate barometer. A common approximation is made by assuming that normal atmospheric pressure at sea level is 14.7 psi and that this value decreases ½ lb per sq in. for each 1,000-ft rise in elevation.

Problem: What is the absolute pressure corresponding to a reading of the vacuum gage of 28 in. of

Table II. Relations of pressure units

	Pounds per Square Inch	Pounds per Square Foot	Inches of Mercury	Inches of Water	Feet of Water	Ounces per Square Inch
1 lb per Sq In.	1.0	144.0	2.037	27.684	2.307	16.0
1 lb per sq Ft	0.007	1.0	0.0141	0.192	0.016	0.111
1 In Mercury	0.4912	70.733	1.0	13.596	1.136	7.859
1 In Water	0.0361	5.203	0.0735	1.0	0.0833	0.5774
1 Ft Water	0.4335	62.425	0.8819	12.0	1.0	6.928
1 Oz per Sq In	0.0625	9.0	0.1275	1.732	0.1433	1.0
1 Atmosphere	14.696	2116.3	29.921	407.27	33.94	235.14

Table III. Relations of power units

	Ft lb per Sec	Ft lb per Sec	Btu per Sec	Btu per Min	Horse-Power	Watts
1 Horsepower	550.00	33,000	0.7075	42.41	1.0000	745.7
1 Kilowatt	737.80	44,267	0.948	56.88	1.3414	1000

Table IV. Relations of energy units

	Ft Lb per Hr	Btu per Hr	Hp-Hr	Watt-Hr	Kw Hr	Metric Hp-Hr
1 HP-HR	1,980,000	2,544.1	1.0	745.7	0.7457	1.0139
1 KW-HR	2,656,000	3,412.75	1.3414	1000	1.0	1.360

Table V. Flow equivalents

	Cu Ft per Sec	Cu Ft per Min	U.S. Gal per Min	U.S. Gal per HR	Pounds of Water	
					per Min	per Hr
1 Cu Ft per Sec	1.0	60	448.83	26,930	3741.0	224,460
1 Cu Ft per Min	0.0167	1.0	7.4805	448.83	62.35	3,741
1 Gal per Min	0.00223	0.13368	1.0	60	8.335	500
1 Gal per Hr	——	0.00223	0.0167	1.0	0.139	8.335
1 lb per Min	——	0.01604	0.1200	7.20	1.0	60
1 lb per Hr	——	——	0.0020	0.1200	0.0167	1.0

For Power and Energy Units, see Keenan & Keyes Steam Tables, page 77. The temperature of water has been taken as 62 F. Various authors differ on the weight of one cubic foot of water.

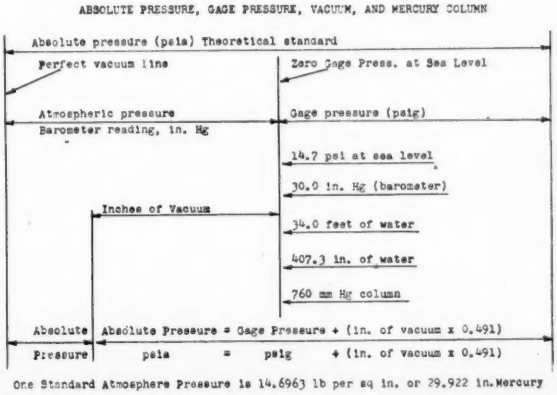

ABSOLUTE PRESSURE, GAGE PRESSURE, VACUUM, AND MERCURY COLUMN
Absolute pressure (psia) Theoretical standard
Perfect vacuum line
Zero Gage Press. at Sea Level
Atmospheric pressure
Barometer reading, in. Hg
Gage pressure (psig)
14.7 psi at sea level
30.0 in. Hg (barometer)
Inches of Vacuum
34.0 feet of water
407.3 in. of water
760 mm Hg column
Absolute Pressure
Absolute Pressure = Gage Pressure + (in. of vacuum x 0.491)
psia = psig + (in. of vacuum x 0.491)
One Standard Atmosphere Pressure is 14.6963 lb per sq in. or 29.922 in. Mercury

Fig. 1. Simple diagram showing relations between absolute pressure, gage pressure, vacuum and mercury column

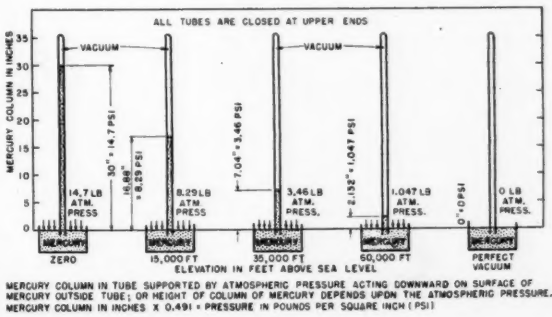

ALL TUBES ARE CLOSED AT UPPER ENDS
VACUUM
VACUUM
MERCURY COLUMN IN INCHES
30" = 14.7 PSI
16.88" = 8.29 PSI
7.04" = 3.46 PSI
2.132" = 1.047 PSI
0" = 0 PSI
14.7 LB ATM. PRESS
8.29 LB ATM. PRESS
3.46 LB ATM. PRESS.
1.047 LB ATM. PRESS.
0 LB ATM. PRESS.
MERCURY
ZERO
15,000 FT
35,000 FT
60,000 FT
PERFECT VACUUM
ELEVATION IN FEET ABOVE SEA LEVEL
MERCURY COLUMN IN TUBE SUPPORTED BY ATMOSPHERIC PRESSURE ACTING DOWNWARD ON SURFACE OF MERCURY OUTSIDE TUBE; OR HEIGHT OF COLUMN OF MERCURY DEPENDS UPON THE ATMOSPHERIC PRESSURE.
MERCURY COLUMN IN INCHES X 0.491 = PRESSURE IN POUNDS PER SQUARE INCH (PSI)

Fig. 2. Diagram showing height of mercury column or barometer reading at various elevations above sea level

mercury when the atmospheric pressure shows a 30-in. barometer reading?

$$p = \frac{14.7\ (30 - 28)}{30} = 0.98 \text{ psia}$$

also $30 - 28 = 2$

and $2 \times 0.49 = 0.98$ psia.

Water has been universally adopted as the standard by which the relative weights of other liquids and solids are determined, this relation is called *Specific Gravity*.

The volume and weight, per cubic foot, of water changes with the temperature; its density is 62.427 lb per cu ft at 39.2 F the point of maximum density.

Water is but slightly compressible, and for all practical purposes may be considered non-compressible. Its boiling point varies with the pressure; the higher the pressure, the higher the boiling point.

For further information on properties of water and mercury, consult the standard engineering handbooks.

NEXT TIME: How heat is added to water to form steam; how to use steam tables, and the Mollier diagram.

Table VI. Fill in blank space for practice in converting units

Data Given	Lb per Sq In	Inches of Mercury	Inches of Water	Feet of Water	Oz. per Sq In
1.0 lb. per sq. in.	1.0	2.037	27.684	2.307	16.0
3.0 "					
11.5 "					
28.0 "					
1.0 in. Mercury	0.4912	1.0	13.596	1.136	7.859
3.0 "					
11.5 "					
28.0 "					
1.0 in. water	0.0361	0.07355	1.0	0.08333	0.5774
3.0 "					
11.5 "					
28.0 "					
1.0 ft. water	0.4335	0.8819	12.0	1.0	6.928
3.0 "					
11.5 "					
28.0 "					
175.0 "					
1.0 oz. per sq. in.	0.0625	0.1275	1.732	0.1433	1.0
3.0 "					
11.5 "					
28.0 "					

Note: Unit values are taken from Table II. When extreme accuracy is required consult Keenan & Keyes Steam Tables and Engineering Handbooks for density of mercury and water at different temperatures.

Liquid pressures are usually expressed in the height of a column of the liquid measured in inches or feet at the point under consideration

How to Align a Four-Bearing Turbine Generator Set

By EUSEBIO QUINTERO

IN A four-bearing turbine-generator set, Fig. 1, both turbine rotor and generator rotor are mounted on two bearings each. The two turbine rotor bearings and the turbine side generator bearing are mounted on the turbine casing. The exciter side generator bearing is mounted on the exciter soleplate. The tie between the turbine rotor and the generator rotor is made by a flexible coupling. This coupling consists of two hubs wedged one on each shaft. These hubs are keyed to flanged sleeves that form a flexible connection between the hubs.

Fig. 1. View of a turbine generator set under erection

The first step will be to locate the generator at the exact position it is to occupy in the building and to level it as accurately as possible. A special piano wire must be set through the horizontal center of the generator. This wire must be supported outside the machine and with the same tension at both ends.

The next step will be to place the exciter side generator bearing. Axially this can be done by locating the center line of the bearing support coincident with the wire. Vertically it can be done by the use of a curve giving us the sag of the wire. This curve shows relations between the size of the wire, the weight at its ends and the distance between the supports, Fig. 2.

The turbine casing with its three bearings must be placed in the same manner. These three bearings are aligned at the factory, and so we have to position, axially and vertically, only the steam end bearing of the turbine and the turbine side generator bearing.

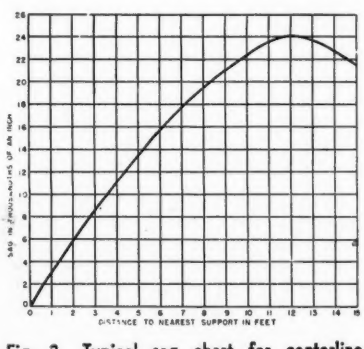


Fig. 2. Typical sag chart for centerline alignment wire

Once the four bearings are aligned and the bolts of the unit tightened, it is time to set the generator and turbine rotors in place.

The generator rotor must be centered magnetically with the stator; it usually has a mark scribed on the shaft at the turbine end to line up with a finished surface on the frame when the rotor is in the magnetic center. The air gap should be checked at each end. The difference between maximum and minimum

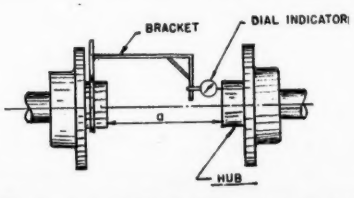


Fig. 3. Use of dial indicator and bracket to check angular alignment of coupling

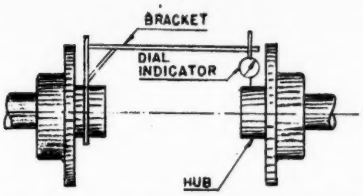


Fig. 4. Use of dial indicator and bracket to check parallel alignment of coupling

measurements should not exceed $\frac{1}{32}$ in.

Extreme care should be taken in handling and placing the turbine rotor. Correct clearances must be maintained between the nozzles and bucket assembly, and between the ends of the thrust bearing. Correct thrust bearing clearance can be accomplished by removing or adding shims.

When the turbine rotor and the generator rotor are exactly located, the hubs of the coupling must be separated by the dimension that will be found stamped on the alignment surfaces of the hubs.

Next, the alignment of both rotors should be checked. Flexible coupling will not compensate for any appreciable misalignment. The same care should be taken in the alignment of a flexible coupling as if solid coupling were to be used. When the faces of the hubs are parallel, the rotors are angularly aligned. Distance "a" Fig. 3, between two fixed points in the faces of the hubs must be the same in all the positions of the rotor.

To check this we can use a dial indicator mounted in a bracket, Fig. 3, fixed on one of the rotors, with the pin touching the face of the other hub. If the readings of the dial indicator are the same when both rotors are revolved, the rotors are angularly aligned.

The sides of the hubs of the coupling must be parallel in order to have the rotors aligned. To check this, we can use the dial indicator mounted in the bracket of Fig. 4 fixed on one of the rotors and with the pin touching the side of the other hub. Next we turn the rotor in which is mounted the bracket and every 90 deg take readings of the dial indicator. When all the readings are the same, the rotors are aligned.

Next we can proceed to grouting of the unit. When the grout has thoroughly hardened, check the alignment again. Final check on alignment must be made after unit has been in service a few hours under normal operating conditions.

The exciter can be aligned to the generator in the same manner. The generator journals are considerably larger than the exciter journals and will ride somewhat higher than the exciter as the oil film forms in the bearings. For this reason the exciter should be set 0.002 to 0.004 inches higher than the generator. This can be accomplished by adding or removing shims between the exciter base and the soleplate. On account of the axial movements of the generator rotor and its expansion when it comes up to operating temperature, the exciter should be located axially so that there is at least $\frac{1}{16}$ in. clearance between the hubs of the exciter coupling, when the exciter is at the inner limit of its own end play.

Fig. 5. View of dial indicator rig for checking angular alignment

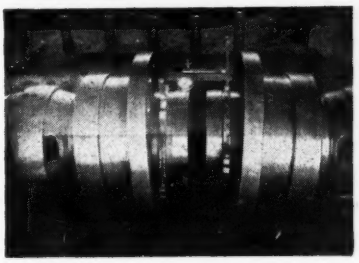


Fig. 6. View of dial indicator rig for checking parallel alignment

PRACTICAL ENGINEER SECTION

FUEL OIL ADDITIVES

THE INCREASED INTEREST, as well as extensive selling of fuel oil additives warrants some discussion, both on the types used, and benefits to be derived from their application.

The formation of sludge in fuel oil, particularly grades No. 5 and 6, has long been a problem which has been accepted as inevitable, and therefore tolerated, because it was believed to be impossible and impractical to eliminate this condition. Sometimes the sludge is delivered with the oil, but in almost all cases

"Darnit, Jones, if you want to borrow a wheelbarrow overnight, ask for it. But don't try sneaking off with it!"

the sludge in a storage tank, results from the reaction within the oil itself, due to type of oil, refining methods, as well as outside sources, such as, condensation of water, excessive heat, and contamination from dirt, rust, and grit.

With the coming of fuel oil additives, this condition can be prevented and eliminated under certain conditions, and with the proper type of additive, as well as obtaining a more efficient combustion, resulting in a cleaner combustion chamber, increased heat, and less smoke.

The chemical and physical composition of these fuel oil treatments are many and varied. Some are simple mixtures, while others are quite complex. Some are good and beneficial, while others have little value. In fact, some are harmful to use, which makes their recommendation a hazardous item. It is not absolutely necessary that we know the exact structure of the material, but it is helpful, as certain types of additives will do better work than others. Listed below are a number of different compositions:

1. Coal tar distillates
2. Petroleum sulfonates, dissolved in kerosene or fuel oil distillates
3. Naphthalene dissolved in fuel oil distillates
4. Naphthalene and caustic soda, in powder form
5. Certain types of alcohols, and solvents

The advantages and benefits to be obtained with the use of these additives are many, but not as numerous as some of the suppliers would have you believe. Some of their claims are greatly inflated, while other claims have been justified and proven under actual test. The following results were obtained using a No. 5 fuel oil treated with a fuel oil additive in the proportion of 1 quart per 1000 gallons of oil. The burner was a steam-atomizing type, under a horizontal boiler.

1. Easier starting, no flash-back
2. More even flame
3. Less sparkling
4. Less soot and smoke
5. Cleaner combustion chamber

There have been some extravagant claims regarding extensive reduction in viscosity of the fuel oil, but in laboratory tests, the greatest reduction using a 1 per cent treatment, was 6.9 per cent. The percentage of treatment recommended by the various suppliers range from 0.025 per cent to 0.0125 per cent, so when used in those ratios, the reduction in viscosity would be quite negligible.

From the results obtained in the laboratory and in actual use of these additives, it should be possible to benefit by their use in various fuels. Most of these additives are good solvents, and emulsifiers. They should dissolve tank sludge if used continually, as well as keeping it in suspension, thereby burning it, instead of accumulating on the bottom of the tank. Due to their solvent action, they should also prevent formation of sludges.

It should be remembered, that these materials are not miracle workers, and should be used where they have a fair chance to perform. It is not possible to turn a tank full of sludge into perfectly good oil. For best results where there is a sludge accumulation on the bottom of a storage tank, some good clean oil should be present, as these additives will mix well with this good oil, and slowly dissolve the sludge. Sometimes the initial charge is not sufficient to complete the job, so additional treatment would be required.

When purchasing and using these fuel oil additives, the important item to remember, is that not all these treatments now on the market are good. There are a number that would be harmful to use; therefore, before using any of these additives, they should be investigated. One of the main and most important requisites for an additive is its solubility in the oil. Unless it is completely soluble in the fuel oil, it cannot function properly. One case of note recently, has been an additive that when added to straight-run oil was insoluble, but when added to a cracked oil, dissolved. After 15 minutes it precipitated a black viscous sludge, from a No. 3 fuel oil distillate. This type of material would be detrimental to use.

The method of introduction is usually pouring the correct amount of treatment into the storage tank before pumping oil into it. Agitation by air pump will distribute the treatment with more efficiency, but it is not necessary in the majority of cases, as the additive will permeate throughout the tank. Where the sludge is viscous and concentrated, agitation of the mixture may be absolutely necessary.

The cost of these fuel oil treatments ranges from $1.25 to $6.00 per gallon. Some of these treatments are sold by the pound instead of by the gallon, but the cost averages as shown by the gallon. These prices are quite high, when compared to the actual cost of the material. The amount usually recommended is 1 pint to 1 quart for each 1000 gallons of oil.

PRACTICAL HINTS AND KINKS

POWDER-ACTUATED HANDTOOL FASTENS STEEL TO STEEL

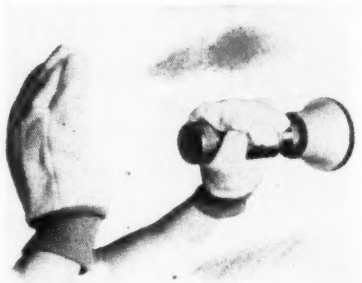
By JOHN G. REYNOLDS

ONCE IN A WHILE a new tool comes along that makes the eyes of our repairmen and maintenance men beam out with that well-known "Now, this IS something!" look. Right now, in our own plant, we have such a tool that is performing many fastening jobs that formerly required the use of motor generators, cables, air lines and other bulky and expensive equipment.

Known as Tempotool, the relatively small hand tool is powered by the force of an exploding powder charge, which acts as a hammer to drive the stud home in steel, concrete or masonry. The high velocity of the stud is such that it imbeds itself firmly.

In our plant, new and specific uses for Tempotool are being discovered daily and it has proved it on many jobs requiring the fastening of light-gage steel (up to ⅛ in. mild) to other steel, concrete or masonry. Laboratory tests have proved that the stud will withstand well over 500 lb direct pull when embedded in sound concrete and, of course, the holding power in steel varies with steels of different types.

The new tool embodies four major safety features, which make accidental discharge or other mishap practically impossible. First the unit has a twin safety feature built into its firing mechanism. A cam arrangement makes it necessary to turn the tool manually into firing position and hold it there. When the turning tension is released, the tool automatically snaps back into safety position. In addition, the inner barrel must be forced back by pressing against the working surface before the firing pin can be engaged. Finally the tool must be hit sharply on the handle before it will fire.



Powder-actuated repair and maintenance tool in use

Other safety features include a special safety shield and a heat-treated alloy barrel.

Tests have proved that even an unskilled operator can load and fire the tool in an average of 30 sec; while, with a little practice, it can be done in less time. In fact, there are only seven easy steps for loading and firing the tool. These steps are as follows:

(1) Unscrew barrel, remove the breech plug, and insert the stud in the barrel of the tool.
(2) Select the proper powder load for the type of material with which you are working and insert it in the breech plug. Because of the variation in density of materials (steel, concrete, masonry, etc.) three loads of different powders are available. The wadding of each powder charge is colored to identify its strength; green wad is for light charge; yellow for medium charge; and red for heavy charge.
(3) Insert breech plug containing powder load in barrel, making sure that the firing rim of the powder load is uppermost in the barrel.
(4) Screw barrel to tool, making sure that barrel is held upright so that breech plug and stud will not fall out before barrel is securely fastened.
(5) Set tool against object to be attached—holding the end of the tool in the right hand and barrel housing in the left hand. Twist right hand to left and at the same time press end of barrel flat against the working surface. The combination twist and pressing releases the double safety and forces the innerbarrel back to firing position.
(6) Keeping forward pressure on the tool, grasp tool in left hand and hit end of tool sharply with right hand. This action fires the tool.
(7) After firing, unscrew barrel and remove breach plug, spent powder load and shear flange.

Four types of studs usable with the tool add to its versatility. For jobs where direct fastening of steel to steel, or steel to concrete or masonry is required, the long shank drive pin is preferred. For direct fastenings of light gage metal to very hard concrete or mild steel up to ⅜ in. thick, use the short shank drive pin. For use where the stud is to act as an anchor for objects attached to it with a standard nut, use the long shank threaded stud (thread size ¼ in. by 20⅝ in. full thread; shank length 1¼ in.). The short shank threaded stud is the same as the long shank threaded stud except it has a ⅝ in. shank and is for use where a long shank is not required.

DEVICE TO LOCATE FAULTY JOINTS IN OVERHEAD LINES

A NOVEL INFRA-RED DETECTOR, designed to locate faulty joints in overhead power line conductors, is described in a report now available from the Office of Technical Services, Department of Commerce.

Designed in the laboratories of the National Research Council of Canada, the instrument is tripod-mounted, and used like a surveyor's transit. It is optically pointed to the power-line and electrically records temperature differences between the conductor and the joint by means of thermal radiation focussed on a bolometer by a parabolic reflector.

The most satisfactory design employs a thermistor-type bolometer in an a-c bridge circuit, according to the report. Signals from this bridge, amplified by a conventional a-c amplifier with a phase sensitive rectifier output, operate a fifty microampere zero-center meter, which serves as an indicator that can be viewed simultaneously with the sighting device, so that the operator can see the source of unusual heat.

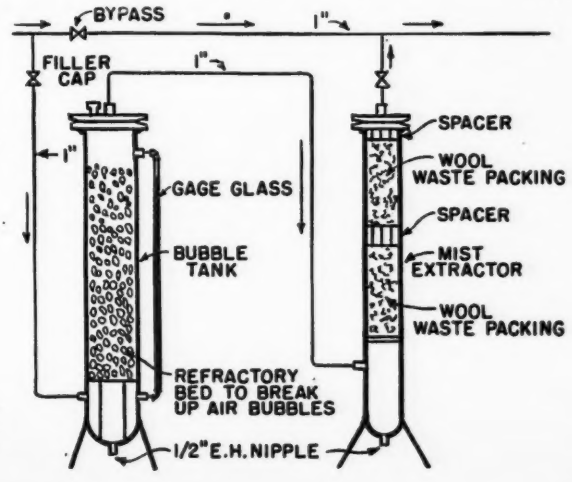
Production models of the detector will be completely self-contained, using sub-miniature tubes and batteries. For easy servicing in the field all circuits will be constructed as plug-in units.

INEXPENSIVE AIR CLEANER

IN OUR refinery we have an extraordinary number of instruments due to the processes involved. These instruments indicate and regulate the entire process. It is therefore essential that they be furnished with a supply of clean air. Each operating unit is equipped with air scrubbing equipment and auxiliary air compressors which cut in at a predetermined air pressure in case the main units fail.

Here is a piping diagram of the inexpensive and efficient air cleaner that we use. The cleaner, when constructed of 12 in. dia pipe and with each tank approximately 6 ft in height, will handle air supply suitable for about 20 control instruments.

Lockport, Ill. G.A.L.



Details of air cleaner used in control instrument piping to improve operation

PRACTICAL ENGINEER SECTION

NEW SYSTEM ELIMINATES RADIO INTERFERENCE WITH INERT ARC WELDING

A NEW SYSTEM FOR the elimination of annoying welder-caused radio interference has been developed by General Electric and is now being incorporated into the manufacture of all G-E Inert-Arc welders.

Other types of welding equipment formerly used for inert gas shielded

An aluminum casing being welded with a General Electric Inert-Arc welder equipped with "balanced wave" system for eliminating the continuous high frequency radio signal emitted by equipment formerly used for inert gas shielded arc welding. An engineer at the left is checking on radio reception

PRACTICAL ENGINEER SECTION

arc welding emit a high frequency radio signal which is a source of frequent annoyance to the radio listening public and to some commercial radio services. By the use of what is called a "balanced wave" combined with a new built-in control, this continuous signal is eliminated, reducing the duration of welder-caused radio noise to a small fraction of a second—an interval so short as to be comparable in effect on radio reception to the flicking of a home light switch.

The result of five years of research by G-E engineers, the balanced wave is used to maintain a constant welding arc in Inert-Arc welding, the most efficient process for the welding of many metals and alloys, including aluminum, magnesium, and copper.

In previously used combinations of ordinary welders with high frequency pilots, the arc was sustained by the use of high frequency radio voltage which forced the sparks across the gap between the welding electrode and the work. According to the engineers, this design caused serious radio interference unless the entire installation was carefully filtered and shielded.

The balanced wave welder eliminates the continuous use of high frequency voltages by balancing the current with a bank of series capacitors, so that pure a-c flows between the electrode and the work. The welding arc is stabilized without the use of radio-frequency energy, thus making filtering or shielding unnecessary.

It was also pointed out that Inert-Arc welders using a balanced wave permit a cleaner, more easily controlled weld, and result in a 25 per cent saving in the argon gas used in this process.

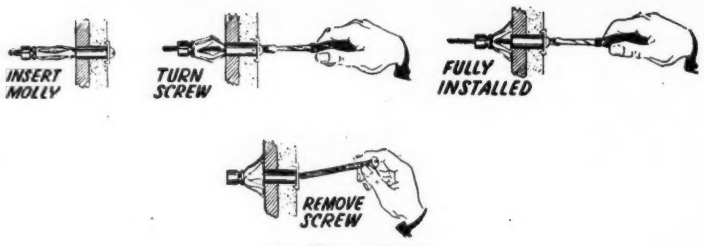
NEW TYPE FASTENER HAS MANY USES

By JOHN G. REYNOLDS

WE HAVE JUST FINISHED giving the old one-two-three test application to a new type fastener that should prove popular around most any plant that has need for a fast, efficient method of fastening equipment to walls, floors, etc.

Our new fastener uses a somewhat different principle than the usual type and provides a definite advantage over other types because it requires a smaller diameter hole and all that is needed to install it are a drill and a screwdriver.

The accompanying figure illustrates the use of this new fixture which is known as a "Molly". The hole is drilled, the unit inserted, and the screw is turned up tight which anchors the stud in the hole as shown. The screw is then removed and reused in attaching the equipment to the wall.



New Type Fasteners

LETTERS AND COMMENTS

INCREASING REFRIGERATION CAPACITY WHEN POWER CAN'T BE BOUGHT

IN THE DECEMBER ISSUE, page 78, A.R.E. gave details of his present meat processing plant, told of plans for enlarging it and said the local power utility company is unable to supply him with any more power. How, he asked, should he remodel and increase his present refrigeration capacity? For the additional power, which he will have to make, should he consider installing a steam generating unit and an engine generator?

At present he has about 12 tons of refrigeration capacity, using freon as refrigerant, with a forced-air circulation system. The present system, he says is not well put together. In enlarging it, should he change to ammonia? He wants to install new motor-driven compressors to carry enlarged refrigeration load of 75 tons; also he needs about 2000 lb of process steam an hour at 10 psi.

George Holman, commenting on the situation, pointed out that he must first determine required temperatures and wall construction and gave data on these. He recommended a direct expansion ammonia system, discussed compressor size and drive.

Following are comments from L. Kenagy. His suggestion of a dual-fuel Diesel generator set is intriguing, also suggestions about steam supply.

Use Ammonia System, and Diesel Generator, says Kenagy

ON THE PROPOSED expansion of the meat processing plant of A. R. E., (P.G., December, 1948, page 78) if I were designing this plant, I would leave the present plant intact with the exception of power. A new power plant could supply the power instead of the 15-kw units now used. One of these units could be installed in the new power plant for lights and also power for small motors in case the main generating units were down.

In the new addition, I would install direct expansion pipe coils, using ammonia as the refrigerant. (Ammonia will produce more refrigeration per pound than freon.) I would use thermo valves to throttle and control the liquid ammonia to the coils.

As to the insulation, I would use cork board in the floor only and shredded redwood bark (Palco wool) in the walls and ceiling. A construction manual can be obtained from the company producing this insulation, describing the standard methods of construction.

For the motors I would use high-torque induction motors, manually

started with a compensator, with low-voltage release and overload protection.

If the freezer requires 10 or more tons of refrigeration, I would install a booster compressor for the freezer. In any event, a separate compressor should be used on the freezer.

For flexibility in operation, I would use 6-by-6-in. compressors, each of which would require a 30-hp motor. For 75 tons of refrigeration you probably would need three of these 6-by-6 machines in addition to the booster compressor.

With the present power load added to the new installation, you would have over 100 hp and probably would need a 150-hp engine. Better results would be obtained if the load on the engine does not exceed 80 per cent of rated horsepower.

If natural gas is available, I would consider natural gas as fuel for one engine, and as you want 100 per cent stand-by power, the other unit could be a Diesel of the same capacity. As a comparison of the two fuels, 145 cu ft of natural gas (1000 Btu.) is equal to one gallon of fuel oil.

If available in this size, the dual-fuel engine should not be overlooked. (This is a Diesel engine that burns either oil or gas fuel. (See P.G., January, 1948, page 118; July, 1948, page 48).

As to the 2000 lb per hr of steam at 10 psi I would install waste heat boilers to utilize the heat of the engine jacket water and exhaust gas. I doubt if you would get 2000 lb per hr of steam from an engine of this size, but it would sure help. You can get this information from the manufacturers of waste heat boilers.

(Editor's Note:—How about using engine exhaust and jacket water to heat feedwater and making all the steam with a "package" steam generating unit arranged for burning either oil or gas?)

I have designed a plant similar to this one, only not as large. It consists of one 25-kw and one 37½-kw. generating units using natural gas as fuel. The engines are equipped with engine safeties, which stop the engine in case the water gets too hot or the oil pressure fails. The ammonia compressors are equipped with high-pressure cutouts. This plant runs from 6:00 p.m. until 8:00 a.m. without an attendant. In operation since 1936, this plant has been very satisfactory both from the standpoint of operation and economy.

Newton, Kans. LELAND KENAGY

HOW A BAD GASKET MADE THE FEED PUMP BALK

By ALBERT H. MOULTON

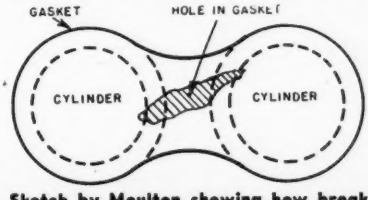
MANY YEARS AGO when I got my first job as a fireman in a granite cutting plant, I used to help the Chief whenever he needed a hand in overhauling and repairs. I started in on this job without any previous experience whatever and had to learn "the hard way," that is, by trial and error (and at first lots of error) but I was young and willing and the old Chief did his best to help me along.

This plant had three HRT boilers, hand fired and fed by a small duplex steam pump and an inspirator. Normally we used the pump, so as to obtain the exhaust steam from the bumpsteam end (and also from steam-driven air compressors) for heating boiler feed. This pump had been in service many years and needed repairs. The steam pistons were leaking badly so new rings had been ordered. When they arrived, the Chief wanted to put them in as soon as possible. Since we had only one feed pump and did not want to feed the boilers by injector, we decided to do the job the following Sunday, the old Chief doing most of the work and I giving him a hand when I could.

We removed the cylinder heads and pistons, found two broken rings and the others badly worn, took out the bad rings, put in the new ones, tightened up the piston rod nuts and put the head back on—and then tried to start it up. Well, it made one stroke on each side and there it stopped. We barred it back to the starting position and tried again with the same results. It started readily to move both pistons to the end of the stroke toward the water end and there they stayed until pushed back again with a bar.

The Chief was puzzled. Never in his forty odd years' experience had he run into anything like that. So he decided to open the valve chest; there might be something wrong there. But no, the valves were O.K., the lost motion correct and the valve seats tight. Nothing seemed to be wrong and yet she "wouldn't work." So he decided to take the cylinder head off again and have another look inside. He looked things over while I barred the pump back and forth, then tried the piston rod nuts to make sure they were tight. Nothing wrong inside. So still puzzled, he told me to graphite the old gasket, which had come off with the cylinder head, and save cutting a new one.

Now as stated before, this was a small pump, size 5½ by 3½ by 5 in. and the two cylinder heads were cast in one piece, making a spectacle shape as shown in the sketch. When



Sketch by Moulton showing how break in gasket prevented pump from stroking properly

PRACTICAL ENGINEER SECTION

I started to smear on the graphite and cylinder oil "goo," as we called it, I noticed that there was a small piece of packing broken out of the gasket at the division line between the cylinder heads. Seeing this, I asked the Chief innocently enough if that could possibly have anything to do with the trouble?

He took one look at that hole in the gasket, and yelled "Well, I'll say it could! Boy, you have found the trouble!" So we put in a new gasket, started the pump and this time it ran fine.

You see, that hole in the gasket allowed steam to enter both cylinders at the same time, pushing both pistons to the end of stroke and holding them there. Apparently the gasket was just about ready to let go when we took the heads off and we did not notice that it was broken when we put them on after replacing the rings.

THE HUMAN FACTOR

IN THE PRODUCTION of goods employing men and machinery we are dealing with two controlling factors and a result: the man, the machine, and the efficiency achieved.

The relationship between these factors is both interesting and vital. Everyone recognizes that improvement in either the man or the machine improves the result measured in terms of production or of unit cost.

Today manufacturers look principally to improvement of the machine equipment to secure the required results.

Yet we have all seen demonstrations of the large possibilities which are latent in the improvement of the human factor.

One of many such cases from my personal experience comes to mind. I wanted to know the every-day efficiency of a certain boiler plant when the operatives were performing under usual undisturbed conditions. My assistant went in advance to prepare the plant for a test which would be run when I arrived on the scene, and he so informed the staff.

But in the meantime my assistant secured records of CO_2 and flue temperature from which the efficiency could be closely approximated.

When the formal boiler test was started, the engineer and firemen were carefully informed they were to proceed as in every-day routine and to make no special effort for us as we wanted to know the regular average performance.

The result of this test under the unavoidably more stimulating atmosphere indicated an improvement of nearly 20 per cent more steam

PRACTICAL ENGINEER SECTION

per pound of coal as compared to the earlier readings.

You can combine a highly efficient machine with a low grade operator and get poor results just as you may have a skillful operator who can go only so far with poor equipment.

The relationship between the three factors can be expressed very simply by the formula: Efficiency = E × H, in which E is the attainable efficiency of the machine equipment and H the applied efficiency of the human factor. Thus if your E rates at say 90 per cent and your H at 70 per cent your efficiency will be 63 per cent. Raising the efficiency of either factor by a given percentage has the same effect on the end result.

As I see the present picture, Labor depends upon Management to improve machine efficiency in order that it may secure a greater return for its contribution. I agree that this is excellent as far as it goes and it has gone far indeed. The application of power machinery to production is the foundation of the prosperity of our country and of the highest scale of living ever enjoyed by wage earners anywhere in the world. So much for factor E.

But in view of our formula it would be interesting to speculate upon the effect of improving the efficiency of the human factor to the extent of even a fraction of what has been learned and accomplished with machinery.

That gets us into labor-management relations, incentives, training, unions, strikes, absenteeism and all the rest of it, not to mention profit-sharing for which I would like to put in a little private plug of my own. So we have the most difficult problem of all to deal with, the human factor, and this applies to the whole world, where, as the old hymn says, "only man is vile."

But that is our job today not only in our factories, in our homes, our nation but throughout the whole structure of human society.

We must study the human factor of our equation with all the ingenuity and patience and understanding and cost that we have put into the development of our wonderful machinery. The dividends in the form of peace and satisfaction and sympathetic understanding of our fellow workers, not to mention the material blessings, will then far surpass those marvelous results of the machine age of which we are so justly proud.

It is high time to inaugurate a new era. Let us name it and make it the human age.

DAVID MOFFAT MYERS

HE CAME ASHORE—HE SAW—HE WAS CONQUERED—HE WENT RIGHT BACK TO SEA!

THE OLD SALT LEANED over the rail and watched the placid waters of the Bay slide by. Sure was good to be home again. In what was an unusually reflective mood for him, he was rapidly coming to the conclusion that marine life was not all that it was cracked up to be. After all, why put up with that brass-pounding idiot in the pilot house, or that belly-robbing pirate in the galley, when one had a fine home ashore and an excellent cook, who also had many other pleasant characteristics?

Besides, the Old Salt had heard rumors of fine jobs to be had ashore. Jobs where one knocked off at 5:00 p.m., and had little to do with the job till next morning.

A Man of Action

Well, the Old Salt was not only a man of the world, but a man of action besides. Once ashore he contacted his wife's uncle's brother-in-law, who had a friend at Gotham Manufacturing Co. In no longer time than it would take to throw a hand line, the OS was instructed to report to the Chief Engineer at Gotham, where a job as watch engineer was vacant.

An early riser, he also wished to look below decks before contacting the Old Man, so 7:30 a.m. Monday saw him rolling into the Gotham plant, and watching, with consuming interest, the goings on. The watch engineer had informed him that the Chief would not be around until about nine ("Big night, you know") and then excused himself on the ground that the day load was coming on, and a larger unit need starting.

The OS noted that a 750-kw engine unit was operating, and was carrying the load which already had built up to 800 kw; doing nobly, too. The OS strolled over to watch the starting of the large engine unit, a twin-cylinder, 1500 kw horizontal job, of popular and recent make. "Might as well learn something," thought the OS.

Starting the Larger Unit

To the amazement of the OS, the watch engineer made no check of the unit. He simply opened the exhaust valve, then, barring open the steam throttle, he let the heavy unit come right up to speed. In pop-eyed fear, the OS recoiled, and stood back, watching and listening to this amazing performance. But he had seen nothing yet! The big engine hissed and banged but held together, to the everlasting credit of its designers.

The watch engineer went to the switchboard, and, without further ado, pulled the main generator switch on the operating unit. The field switch and exciter switch were next. The small engine seemed to leap from its foundation, but quickly settled down. "Really, a fine governor" mused the OS. But what kind of a plant was this?

The watch engineer murmured something about "indirects", a new word in power plant nomenclature, as far as the OS was concerned, and went to the rear of the board, and pulled the disconnects on the smaller unit, and closed those on the unit just started. Coming to the front of the board, the watch engineer pulled the polarity switches of the smaller unit, on the voltage regulator, and closed those of the large unit. The single pole switches were all closed, and evidently never used.

After closing the exciter main switch and the field switch on the large unit, without even looking at the meters, the watch engineer slammed home the main generator switch. The generator gave a grunt, the exciter belt squealed, while the watch engineer held frantically to the governor control switch, trying to boost engine speed. Finally, the old girl got the load under control, and settled down somewhat.

An Un-nerving Experience

Lights in the engine room were very unsteady, rising and falling with suspicious regularity. The OS moved watchfully over to the voltage regulator. One glance showed an unbelievable condition. The main floating contacts were far out of place, the dashpot was full of some sticky fluid, and the relay arms were shimmed with paper strips, evidently in an effort to bring the contacts together squarely.

The OS found the whole experience rather un-nerving, so he repaired to the nearest diner for refreshments. "Just what," he thought, "will the Chief be like?"

Promptly at nine, the OS reported at the office of the Chief. Here was a man. Stocky, powerful of build, bluff and hearty in greeting, the Chief seemed really pleased to meet the OS. Yes, sir, he'd show the new man around the plant, himself.

The Boiler House

The boiler house was the first stop on the itinerary. Four boilers were on the line and apparently steaming mightily. Steam-flow-Air-flow meters of a well-known make were installed, and the OS was interested to note that while the steam-flow pen was high off the chart on three boilers, the three air pens were far low, indicating a serious deficiency of air. Walking past No. 1 boiler, the OS sheered off, for the fire line inside the furnace was clearly shown on the boiler sheathing. Quite some fire—but the Chief seemed not to notice.

The beater room was next. Here huge motors worked busily. Heat waves poured from them. Windings and frames were festooned with typical grey fuzz and scum. Noticing what seemed to be unusual heating of the motors, the OS remarked about the condition. He was in-

formed that that was nothing—nothing, indeed. He should have seen the motors when first installed!

They were then running hot, so the voltage was tested, with the diagnosis of high voltage. And the remedy?—to lower the voltage! So the Chief and his assistant dropped the main generator voltage to 2150. This, for motors rated at 2300 v! The Chief said that the lowered voltage would make them run cooler.

They then passed into the ash room, where a pile of dump grates lay in a corner. The far ends looked badly burnt, and somewhat shortened. The OS was informed that the bridge wall tubes had bulged, and that the grates had hit and dented them. "We cut off the grates, and got them out of sight of the boiler inspector, before he examined the boiler," said the Chief. "But he caught on and gave us hell."

Through the ash room they entered the pump room. One feed pump was running, a fine turbine driven type. But how it roared! Bearings loose, water flying from the shaft packing, steam pouring from the glands, governor rod evidently stuck in place. Some pump! The Chief allowed that you might better hear them than smell them. And so on————

* * *

The waters of the Bay were smooth and quiet. Galveston was several thousand miles distant. Below decks, the Diesels throbbed evenly. The OS spat over the rail and considered matters thoroughly. A shore job had its advantages, yes. But life aboard ship———— He grinned and went below. This was the life—and, likely, a long one.

Questions and Answers

Question No. 436

HOW MEASURE COMPRESSED AIR SYSTEM LEAKAGE?

WE WOULD LIKE to find some means of checking a compressed air system for leakage without having to inspect every line, valve and nozzle throughout the plant. What methods can be used to do this cheaply and effectively?

It seems to us that if we had some type of meter permanently installed in the compressor discharge line, the amount of leakage could be determined during a shut-down period by operating the compressor with all the compressed air outlets shut off.

Then, if the meter were calibrated in cfm, when the leakage reached some predetermined value, a systematic search could be made to find the leaks and repair them.

Who can suggest other and better ways of doing it?

Chicago, Ill. F. N. B.

Use a Clock, Says Wollner

IF YOUR COMPRESSOR is motor-driven and equipped with an automatic starter that cuts in at a predetermined minimum air pressure and cuts out at a predetermined maximum air pressure, all you need is to connect an ordinary electric clock to the power line of the compressor driving motor, in such a way that the clock will stop and start together with the compressor motor.

Then, with all air outlets shut off, the clock will indicate whatever time the compressor runs to make up leakage. Multiply this running time by the known capacity of the compressor per unit of time—cubic feet per minute or per hour—and you will have a very close approximation of the leakage in cubic feet during the period.

South Hackensack, N. J. PAUL WOLLNER

Editor's Note: Very ingenious, when you have a motor-driven compressor. What if the compressor is steam driven?

Question No. 437

HOW DESIGN OVERFLOW PIPE FOR CLOSE LEVEL CONTROL?

IN A LARGE water tank, it is desired to keep the water level within close limits. In order to get the desired capacity for intermittent use, it is necessary to carry the upper level within 10 in. of the top of the tank. This level is maintained by a float-controlled hydraulically-operated valve. Water is delivered to the tank by a 200-gpm pump.

To prevent overflow in case the automatic valve should fail to close, a standpipe type of overflow is to be installed to keep water from rising more than 6 in. which would bring it to within 4 in. of the tank top, as shown in sketch.

What size overflow pipe would be required if there is say a 15 ft fall through the pipe? What are the formulas or methods for calculating the size of pipe under the conditions given?

I know that many engineers would say just put in a pipe big enough for the worst condition when the valve sticks wide open and passes the full pump discharge of 200 gpm into the tank. But it seems to me this is side-stepping the problem.

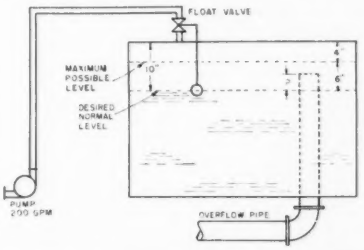


Diagram of A.H.M.'s water tank in which he wants overflow pipe to be designed to prevent level rise of more than 6 in. if float valve fails to close

Under any conditions there will be only a few inches of water—6 in. at most—as head on the overflow pipe inlet. The latter will then be in effect a circular weir but with a head of only very few inches or even fractions of an inch. Will there not be entrainment of air at the inlet, causing cavitation, also higher resistance to flow, vortexes and turbulence at the inlet and other factors that would affect the size of the entrance? In short, you want the overflow to discharge small quantities of water with very small head over the pipe inlet and prevent the level from rising more than 6 in. under any conditions, without causing trouble in the pipe entrance.

Pittsfield, Mass. A.H.M.

Answer No. 429

HE WANTS HELP ON POWER PLANT MAINTENANCE SCHEDULES

IN A SMALL utility power plant of 27,500 kw capacity in four turbine-generator units supplied by four pulverized-coal boilers, said F.T.L. in the October issue, he has been assigned the job of working out maintenance schedules. But he had made little progress, he said, because he didn't know just how to get started. The plant operates as a base load station at rated capacity in a system with small reserve capacity.

We referred him to various PPE articles on the subject, also to other utilities having good maintenance programs. Below is another comment from Sergio Martinez, who tells how they do it in his plant.

PRACTICAL ENGINEER SECTION

Martinez Shows How Card File Keeps Maintenance Schedule

THE BEST WAY to organize Plant Maintenance Schedules is to keep a Card File like the one I keep at our plant. The sketch shows the type of card we use. There is a card for each individual maintenance job, marked with the number of weeks' interval between inspections. A file is kept for each of the 52 weeks of the year and the cards are placed in the file corresponding to the week during which the indicated work is to be done. On the sample card, the last maintenance job was done the third week of October and since it is to be done every 12 weeks, the card was filed in the third week of January, 1949. In the third week of January, all work in that file had been performed and the cards were moved forward the correct number of weeks.

The maintenance card carries the date of performance, comments on the work performed and the job order number. The job orders are issued every week to the maintenance mechanics from the file cards for that week. Upon completion of the work, the mechanics turn in the job order duly signed; then the office clerk files the maintenance card, moving it ahead the correct number of weeks.

This system has proved very satisfactory in the several years we have been using it, since all maintenance is done at the proper time and a complete record is available of the work performed in any piece of equipment.

Cards are kept for jobs such as inspection of turbine bearings, generators and exciter brushes, pumps, boiler furnaces, boiler water tubes, boiler air heaters, water heaters, water softener equipment, and so on.

Havana, Cuba — SERGIO MARTINEZ

THE ATLAS TEXTILE CO., INC.

Engineering Department

MAINTENANCE RECORD

Equipment: Circulating Pump No. 2

Location: Power Plant — 1st floor

Inspect every: 12 weeks

Date			Comments	Job Order No.
Week	Month	Year		
3	Jan.	46	Inspected — Found OK	2469
3	April	46	" " "	2584
3	July	46	Changed thrust ball bearing	2690
3	Oct.	46	Inspected — Found OK	2801
3	Jan.	47	" " "	2889
3	April	47	" " "	3015
3	July	47	" " "	3153
3	Oct.	47	Repacked — 8 turns of ½"	3292
3	Jan.	48	Inspected — Found OK	3360
3	April	48	" " "	3501
3	July	48	Changed radial ball bearing	3593
3	Oct.	48	Inspected — Found OK	3685

Typical maintenance record card as used in Sergio Martinez plant

Answer No. 431

WILL A RECTIFIER SOLVE THIS PROBLEM?

HE IS STUCK with several new 1-hp and ¾-hp 230-v d-c motors, said B.M.M. in the October issue, because he needs motors for driving certain small equipment and he has no direct current. Would it be worth while to rectify his a-c for this purpose, or should he try something else? Sergio Martinez tells here how he can do it with a rectifier but does not recommend it.

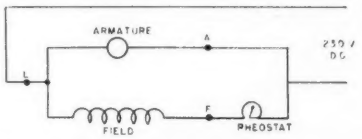


Fig. 1. Diagram by Martinez to show how B.M.M.'s motor, with connections marked A, L and F, should be connected

Better Use Single-Phase A-C Motors, says Martinez

B.M.M. seems to be really stuck with those motors. The ¾-hp must be a shunt motor, arranged to have one end of the line connected at "L" and the other to "A" and "F" as shown on the sketch, and probably through a rheostat.

He can, of course, get a rectifier to operate the motor from the AC line, but I doubt if it will be economical. To obtain 230 v d-c, the rectifier will have to be supplied with about 335 v single phase. This is not a standrad voltage, by any means, and the rectifier may cost as much as the motor.

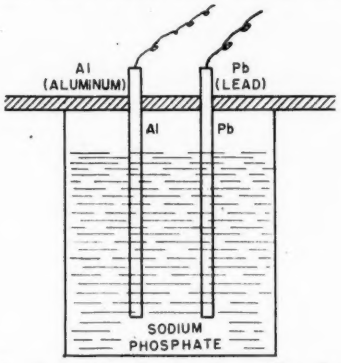


Fig. 2. Design of a simple rectifier, four required for this job

Of course, he can make a homemade rectifier by using 4 glass or porcelain containers, filling them with a solution of sodium phosphate and installing in each container one aluminum and one lead electrode, each of about ½ sq ft area, Fig. 2, and connecting them as in Fig. 3. This layout will work but will require quite a lot of maintenance and still needs the special a-c supply in order to produce 230 v.

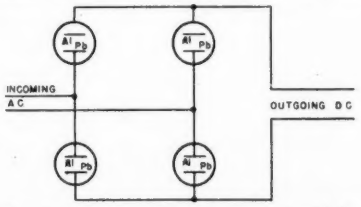


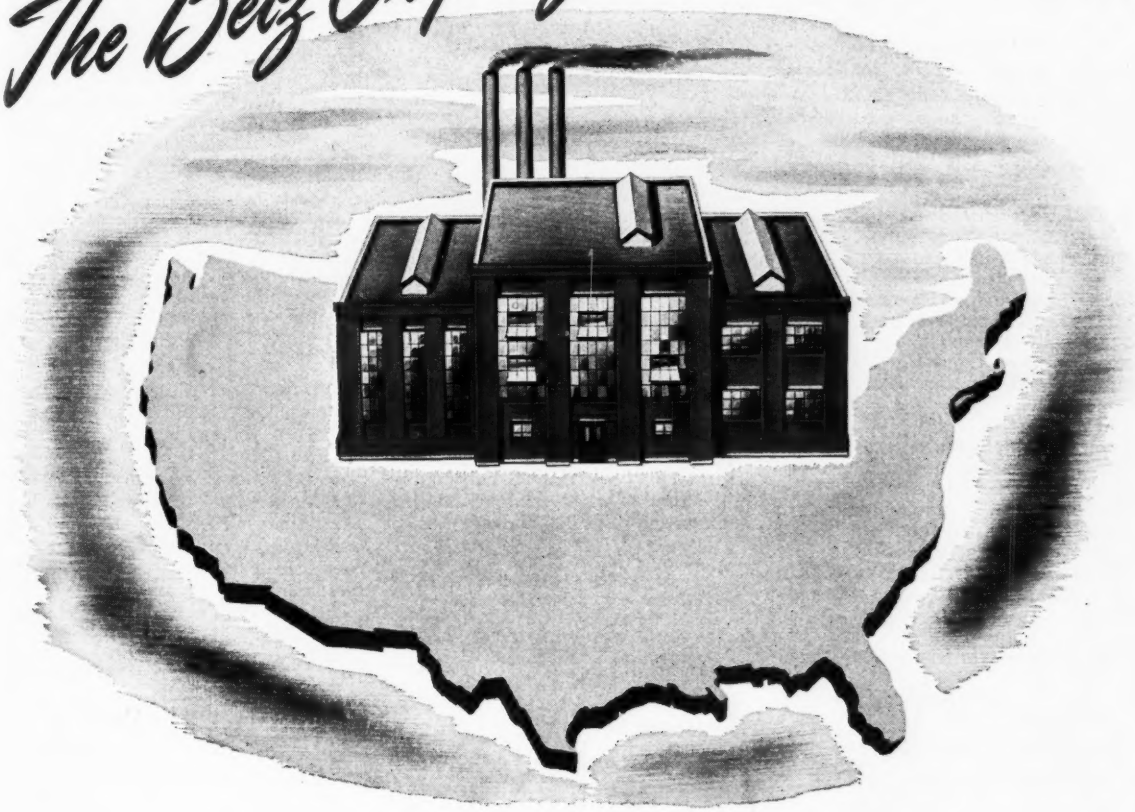
Fig. 3. How rectifiers of Fig. 2 should be connected

I think B.M.M. had better try to return or sell these two motors and buy two single-phase a-c motors.

SERGIO MARTINEZ, JR.

Editor's Note: — *How about the copper oxide or selenium rectifiers? Or a vacuum tube rectifier? Probably too expensive. The contact rectifier would be good if obtainable. (P.G. April, Feb., Sept. 1948).*

The Betz Organization



. . . and your plant

BETZ is a nation-wide organization of engineers and chemists specializing in the solution of problems involving boiler feed water . . . cooling water . . . process water . , . waste recovery . . . stream pollution.

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BOILER WATER CONDITIONING • COOLING WATER CONDITIONING • INDUSTRIAL WASTE TREATMENT

How Ion Exchange Resins Work

Ion exchange "swaps" objectionable ions in water for less harmful ones, or for ions that can be eliminated . . . Ion exchange resins hold ions on their surfaces so that the "swap" can be controlled . . . Three common water treatment methods described in which ion exchange produces either soft water, treated water or demineralized water

BECAUSE PURE WATER never exists in nature, almost no industrial plant using large quantities of water for steam production, or for the process industries, escapes the problem of water treatment. Newly developed ion exchange resins now offer improved control of water quality, and greater selectivity of that control.

Water in the Middle West differs from that obtainable on the Atlantic seaboard; two plants a few miles apart on the same river may have water supplies of entirely different characteristics. Frequently, too, the amount and character of the dissolved materials will vary even with changing seasons in the same locality.

When a metallic salt, such as calcium carbonate (limestone), magnesium sulfate (Epsom salt), sodium chloride (table salt), and the like, is dissolved in water, ionization takes place. The salt tends to dissociate or separate into two electrically-charged components. The metal constituent that has lost an electron assumes a positve charge, while the remainder of the molecule, which has gained an electron, becomes negatively charged. The calciu and magnesium generally occur in water in the form of bicarbonates and sulfates, with possibly smaller amounts of chlorides and nitrates.

What, then, are ions? They are extremely minute particles, which carry either a positive or negative electrical charge, and which are present in a water solution of acids, bases, or salts.

To the engineer, however, the exact nature of the salts is not as important as the fact that when these salts dissociate, they liberate calcium, magnesium, iron, manganese and other metallic ions that may cause boiler-scale. Commonly, in the power field, it is the magnesium and calcium ions that are objectionable. In high-pressure steam plants, silica in the feedwater is often carried over in the steam lines, forming a deposit on turbine blades that rapidly reduces the turbine's output.

What is ion exchange? It is the trading of one charged particle for another, the "swap" that occurs in countless chemical reactions. By homely analogy, it is the lively exchange of partners in a square dance. The number of dancers remains the same, but different combinations result.

Synthetic resins treated to function as ion exchangers have the ability to absorb, or attract to and hold on their surfaces, ions in solution. By trading one charged particle for another, ion exchange allows the plant operator selective control of the "swap" that occurs in countless chemical reactions. It permits him, for example, to remove ionized impurities (including the metallic ions) from boiler-feed and other water supplies.

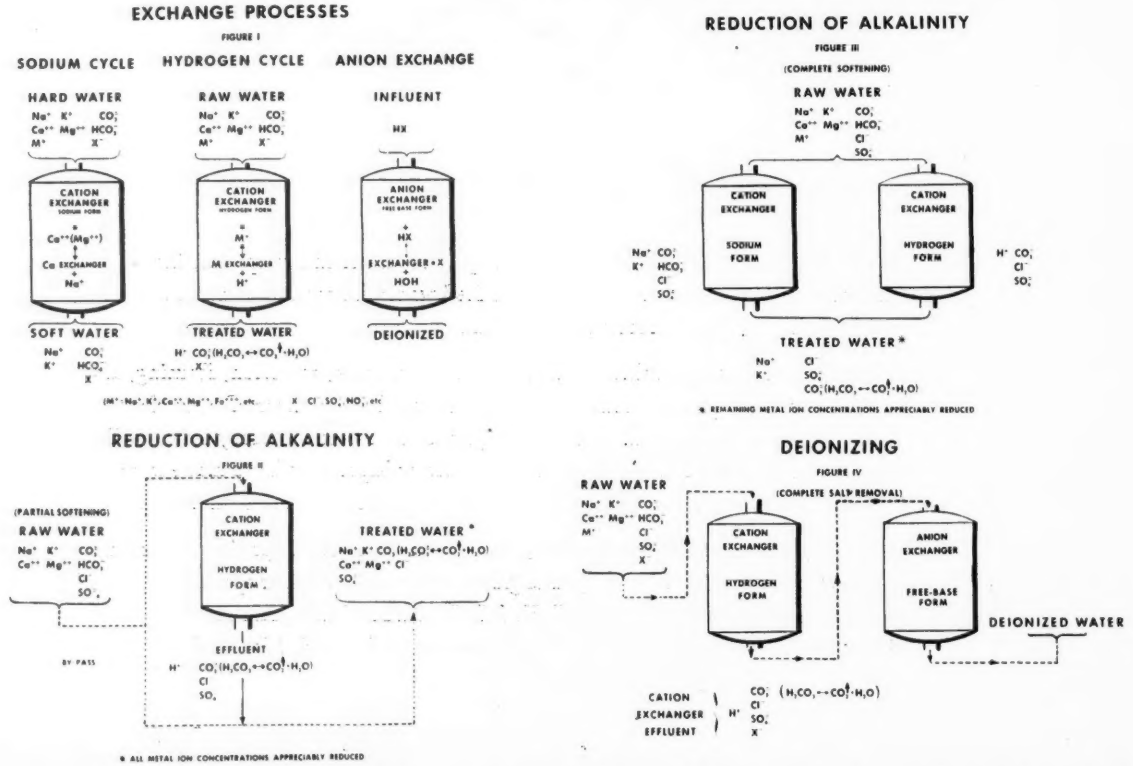

Fig. 1. Methods of treating water by cation exchanger on sodium or hydrogen cycle; and by anion exchanger of free-base form. Fig. 2. Reduction of alkalinity to produce treated water. Fig. 3. Use of cation exchangers, sodium and hydrogen cycles, to produce completely softened water. Fig. 4. Use of cation and anion exchangers for complete salt removal or deionization, to produce water containing less than 5 ppm total solids

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RUBBER PRODUCTS

•

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REG. U. S. PAT. OFF.

An ion exchange resin is a large, insoluble molecule containing reactive groups that have the ability to partake in a trade of ions. The ions adsorbed on the resin molecule make up a "stag line" whose members are waiting to trade places with the dancers in solution.

Method Varies With Purpose

Three water-treatment methods shown in Fig. 1, are widely employed: one will replace objectionable ions with less harmful ones, another will produce a water supply of reduced alkalinity and dissolved minerals, and the third will remove completely all dissolved salts.

Naturally-occurring sands or treated carbonaceous materials are often used to accomplish the first of these objectives.

Softening of water by ion exchange involves merely passing it through a tank or bed of the cation exchange resin which has been treated by the manufacturer with a brine solution to replace its hydrogen ions with sodium ions. Such an exchanger — for example, Amberlite IR-100 or Amberlite IR-105—will remove the calcium, magnesium and other metals. As the water passes over the active exchange centers, sodium replaces the other metallic ions in solution. Since the sodium ions thus placed in solution are not hardness-forming, the effluent water is satisfactory for many purposes including boiler use, washing operations, and so on. In this softening operation there is no reduction in the total solids in the water, but merely an exchange of harmless ions for objectionable ones.

Eventually, of course, the exchange centers on the resin particles will reach an exhaustion point—will have adsorbed metallic ions to the limit of their capacity. When that point is reached, simple regeneration with sodium chloride will restore the resin to its initial activity. When the cation exchanger is thus used in the sodium form, it is said to operate in the sodium cycle.

Softening is the simple replacement of an objectionable ion for a desirable one, as in the replacement of a jitterbug partner for a waltzer at a formal dance.

Another water-conditioning method, Fig. 2, is made possible by ion exchange. Certain raw waters contain quantities of carbonate and bicarbonate salts. These are salts of a strong base and a weak acid, and when they dissociate, a basic or alkaline solution is produced. To reduce carbonate or bicarbonate alkalinity, the cation-exchanging resin in the hydrogen, or free acid, form is used to treat a portion of the water. The effluent from this one-bed system is acidic, since it contains as ions the acids corresponding to the salts which were present in the raw water.

When this acidic water is blended with raw water, or with water which has been treated with the cation exchanger in the sodium form, Fig. 3, carbonic acid is produced and removed by aeration. The result is a water of controlled alkalinity and reduced salt content.

Complete Deionization

Suppose, however, a water is desired that will be free not only from the positively charged metallic ions but also from the sulfate and all other negatively charged ions. This complete removal of all ions from a solution involves deionization, which delivers water as chemically pure as distilled water. To accomplish this, the resin must be used in the hydrogen cycle; that is, its supply of exchangeable sodium ions must be replaced by hydrogen ions — a simple procedure accomplished by merely passing a dilute solution of acid through the resin bed. The water to be ionized is first passed through a column, Fig. 4, containing large numbers of cation exchanging resin particles; in passage, hydrogen ions are released from the resin's acid groups, and metallic ions, such as magnesium, calcium, iron, manganese, etc., are picked up or adsorbed. This first stage of the process delivers a highly acidic effluent, but one which contains no metallic ions.

Now the acidic output from the cation exchanging bed is passed through a bed containing particles of another of these Amberlites—this one an amine-type anion-exchanging resin, Amberlite IR-4B. Here, the hydrogen from the acid groups of the cation exchanger combines with the hydroxyl ion from the anion exchanger to produce water molecules which simply blend with the molecules of the water that has been deionized. The effluent from this 2-bed system is commercially pure—containing less than 5 ppm total solids.

Deionization is the complete removal of all ions from a solution; no positively or negatively-charged particles remain. The water will not conduct an electric current; it is as chemically pure as distilled water.

BUREAU SEEKS BIDS ON SPILLWAY-REPAIR WORK AT GRAND COULEE DAM

THE BUREAU OF RECLAMATION has called for bids on repairing the spillway bucket at the Grand Coulee Dam. The job also will include dredging of the Columbia River channel below the dam, repairs to the spillway face, and related activities.

Work will involve use of a floating caisson, a barge-equipped floating chamber that will be lowered over the spillway bucket to permit men to make repairs below the surface of the Columbia.

The spillway bucket of the giant dam was damaged through erosion caused by boulders and other foreign materials entering the bucket during construction and later, and being continually agitated by the water action in the bucket. Although the erosion has not been sufficient to endanger the stability of the 21,000-000-ton structure, Bureau of Reclamation engineers believe that the repairs should begin as early as possible to avoid further damage.

Opening of bids was scheduled for 10 o'clock the morning of December 21 at Coulee Dam. When the contract is awarded, the successful bidder would have 470 days—nearly 1½ years—to complete the work. The contractor would be required to repair at least 150 ft of the 1,650-ft-long spillway bucket.

The bid-call covers a large number of preliminary operations by the contractor before actually operating the caisson on the spillway. Among these are 163,000 t of dredging, repair of flood-damaged equipment used in maneuvering the caisson, and work on the caisson itself and on the circular drydock in which it was fabricated.

Because of the many preparatory steps, repair work involving use of the caisson will not begin until the low-water season in the fall of 1949. During the present low-water season, the contractor would be required to replace concrete which has been damaged on the downstream face of the spillway. This work, however, is considered a minor undertaking in comparison with the bucket repairs.

Long the subject of engineering studies, the huge floating caisson was built by the Bureau of Reclamation, and rests in a circular drydock on the river's edge downstream from the dam. A channel leads from the drydock to the river. Shaped to fit the curved spillway bucket, the caisson is 115 ft long, 57 ft wide, and 97 ft high. It has four access tubes leading from above the surface of the water to the working chamber below. These tubes carry service lines and also will be used to transport men and materials.

Although the caisson was completed last year and was floated in its drydock, it never has been maneuvered on the Columbia. When the caisson is ready for its first trip to the spillway, a huge segment of the concrete drydock will be broken free and dropped into the channel, exposing two massive steel gates which will be opened to permit the caisson to be moved into the river.

An extensive system of cables, handled by "puller machines" on the banks of the river and on the two powerhouses of the dam will be used in maneuvering the caisson to the spillway.

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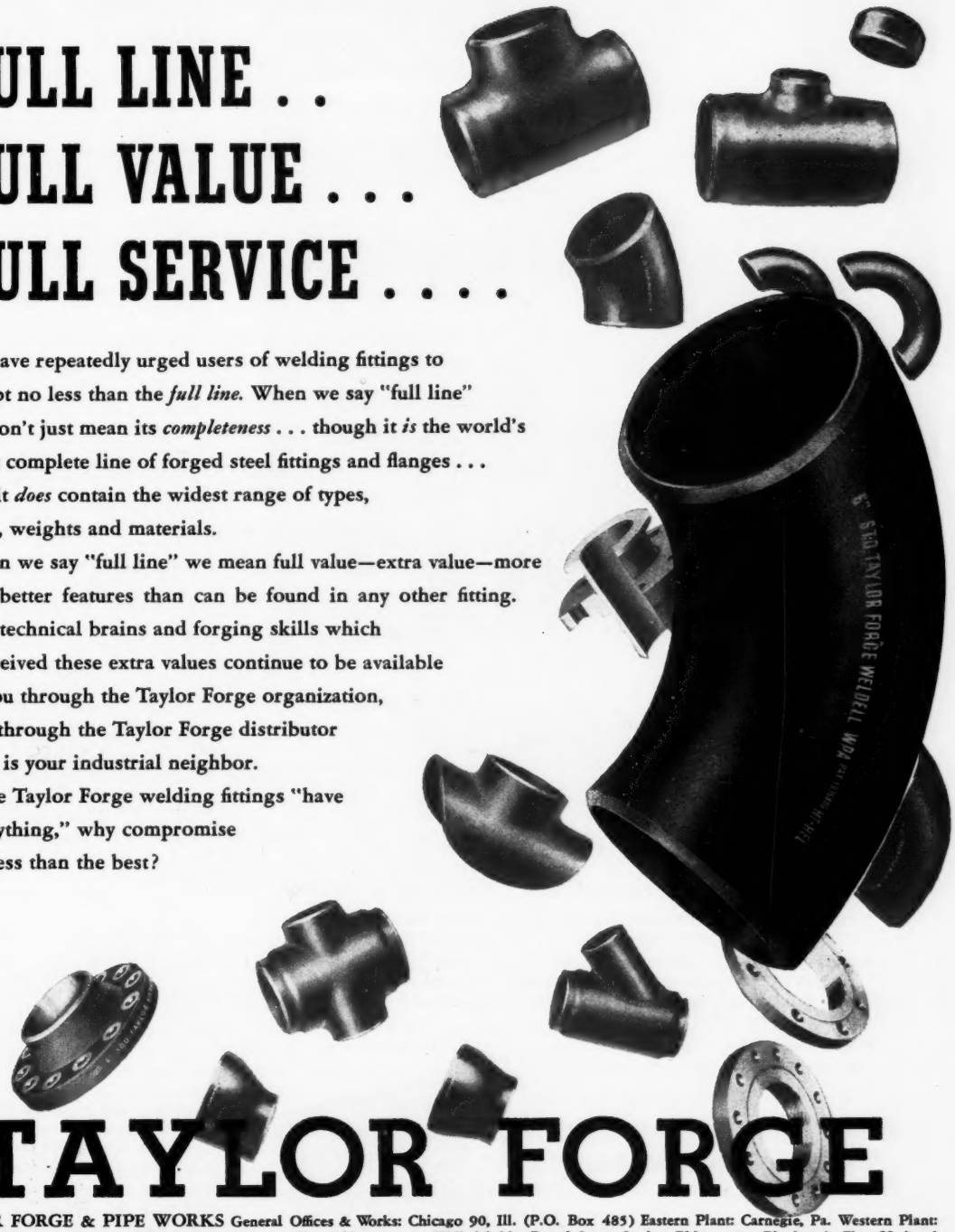
Since Taylor Forge welding fittings "have everything," why compromise on less than the best?



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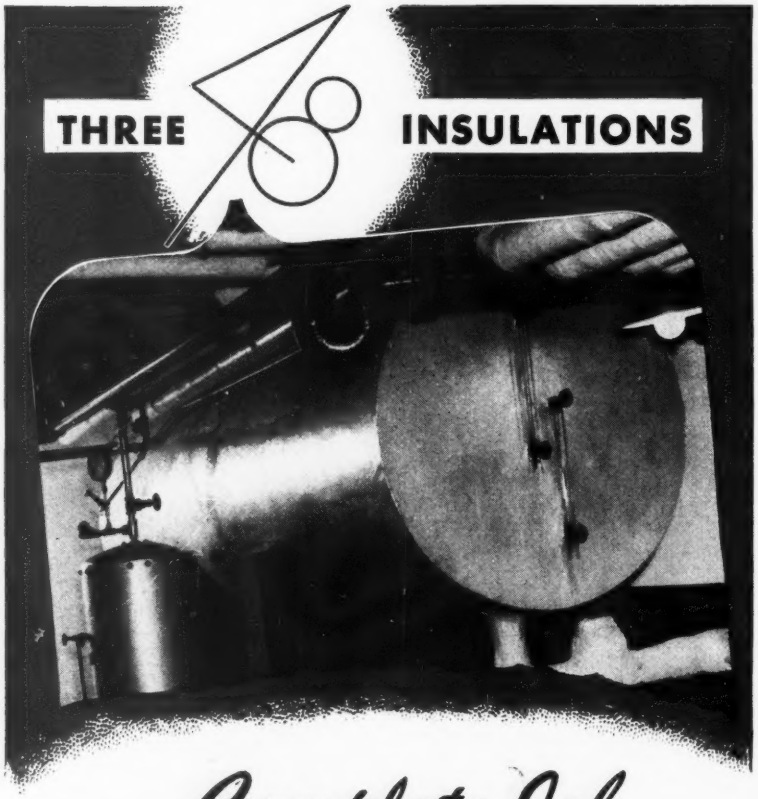

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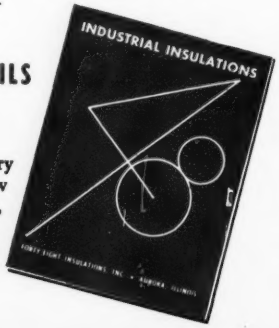


FORTY-EIGHT INSULATIONS
INCORPORATED
AURORA, ILLINOIS

COMING EVENTS

ASTM—The Spring Meeting and ASTM Committee Week, to be held at the Edgewater Beach Hotel, Chicago, February 28 to March 4.

NACE—1949 Conference of the National Association of Corrosion Engineers to be held in Cleveland April 11-14. Headquarters:—Netherland-Plaza Hotel, Cincinnati.

WMCE—The Sixth Western Metal Congress and Western Metal Exposition will be held at the Shrine Auditorium, Los Angeles, April 11-15.

AIEE—1949 Meetings of the American Society of Electrical Engineers, South West District Meeting, Dallas, Baker Hotel, April 19-21; Summer General Meeting, Swampscott, Mass. New Ocean House, June 20-24; Pacific General Meeting San Francisco, Fairmont Hotel, August 23-23; Midwest General Meeting, Cincinnati, Netherland Plaza Hotel, October 17-21.

ASCE—1949 Meetings of the American Society of Civil Engineers, Spring Meeting, Oklahoma City, April 20-23; Summer Convention, Mexico City, July 13-15; Fall Meeting, Washington, D. C., November 2-4.

ISA—The Fourth Annual Spring Meeting of the Instrument Society of America will be held at the Royal York Hotel, Toronto, Canada, May 12 and 13.

NDHA—The 40th Annual Meeting of the National District Heating Assn. will be held at The New Ocean House, Swampscott, Mass., May 24-27.

ASTM—The 52nd Annual Meeting of the American Society of Testing Materials to be held at the Chalfonte-Haddon Hall, Atlantic City, June 27 to July 1.

ASTM—The First National meeting of the American Society of Testing Materials to be held on the West Coast will be held at the Fairmont Hotel, San Francisco, October 10-14.

Midwest Power Show—The 9th Midwest Engineering and Power Exposition will be held at Navy Pier, Chcago, November 11-16.

Obituaries

DAVID P. GRAHAM

DAVID P. GRAHAM, Vice-President of Peabody Engineering Corp. New York City, N. Y., died on December 18th at his home in Westbury, Long Island. Mr. Graham graduated from Stevens Institute of Technology in the class of '23.

Following his graduation, Mr. Graham went to South America as a test engineer for three years and returned to join Peabody Engineering Corp. as Sales Engineer. During his 22 years with Peabody he rose from Sales Engineer to Sales Manager, Manager of Gas Scrubber Division, Ass't. to the President and was later appointed Executive Vice-President which position he held at the time of his death.

GEORGE W. WELLS

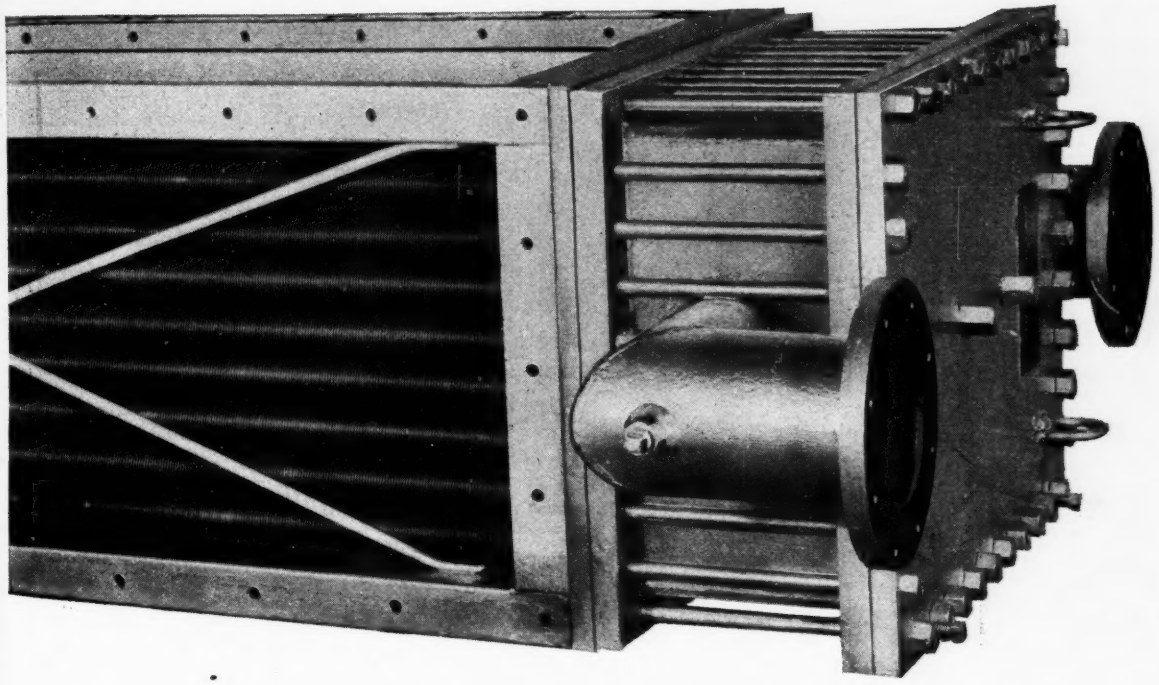
GEORGE W. WELLS, Comptroller for the Superior Engine Division of The National Supply Co., Springfield, Ohio, died Sunday, January 16, in his 66th year. Born at Buchanan, Michigan, January 25, 1883, he had lived in Springfield for the past four years.

Mr. Wells has been associated with National Supply for 45 years—from 1903 to 1936 at the Company's Toledo, Ohio, plant, and from 1936 to 1944 at the Company's executive offices in Pittsburgh, Pa., before being transferred to Springfield.

G-R K-FIN

AIR and GAS COOLERS and HEATERS

Compact and Efficient



G-R K-Fin Units are admirably suited for air and gas cooling and heating duties. The use of K-Fin Elements with mechanically bonded helical fins, requiring no tinning, enables these units to withstand high temperatures and to operate successfully on duties where loosening of fins cannot be tolerated.

One of the distinctive features of the G-R K-Fin Cooler is its cooling surface of superior effectiveness. The K-Fin elements of this unit have helical fins. These fins, forming an extended outside tube surface, provide a higher heat transfer rate for a given air or gas pressure drop than is obtainable with other finned tube coolers.

When used as a *generator air cooler,* the K-Fin unit is embodied in a self-contained, closed, dust-proof and fireproof system, using turbine condensate or other available water supply as the cooling medium.

Some of the many other applications of this unit are for recovering gases from solvents, dehydrating illuminating gas, cooling gases from annealing ovens, and other gas cooling services.

Write for Bulletin 1219 describing all the features of the K-Fin Air and Gas Cooler.

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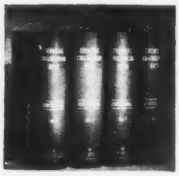

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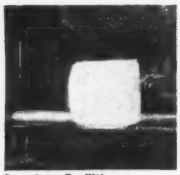

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Top Welding Performance assured by specially designed equipment and exclusive employment of master operators.

Quality Control embracing the constant application of the most advanced inspection methods, both visual and non-destructive.

On-Time Delivery made possible by a flexible planning group authorized to re-route work to meet promised dates.

This fellow starts where the shop leaves off!

THIS welder is on a job site—in a power house far from Kellogg's plant. He's only one of a crew installing power piping which Kellogg prefabricated. But what he and his partners do, away from the critical eyes of the plant metallurgists and technicians, will go a long way toward determining whether the new piping being welded into position stands up to its "built-in" performance possibilities.

Faulty metal formations can on occasion flow from the end of any welding rod . . . locked-up stresses can be established through carelessly controlled heat treating practices . . . even the fitters, who install the temporary supports before welding can cause damaging stresses in this piping that came through plant inspection with flying colors.

Only experience and knowledge of "what not to do" and expert supervision can preserve the basic qualities built into that piping at the plant. And that should be reason enough for purchasers to consider carefully the relative efficiency and quality of installation forces *before placing orders for critical power piping.* For in essence these installation crews establish final performance of installed piping.

The high repute in which Kellogg installation work is held is the result of more than thirty years of daily association with power piping of all types.

It is the result of knowing where and how to apply positive checks of quality!

It is the result of building over the years a force of supervisory personnel capable of assimilating the pertinent metallurgical information uncovered with each additional day's experience.

It is the result of manning each job with trained, tested and experienced piping engineers, welding inspectors, and stress relieving technicians.

It is all of these plus a management approach which demands that Kellogg piping *in the power line* retain every performance property built into it *at the fabricating plant.*

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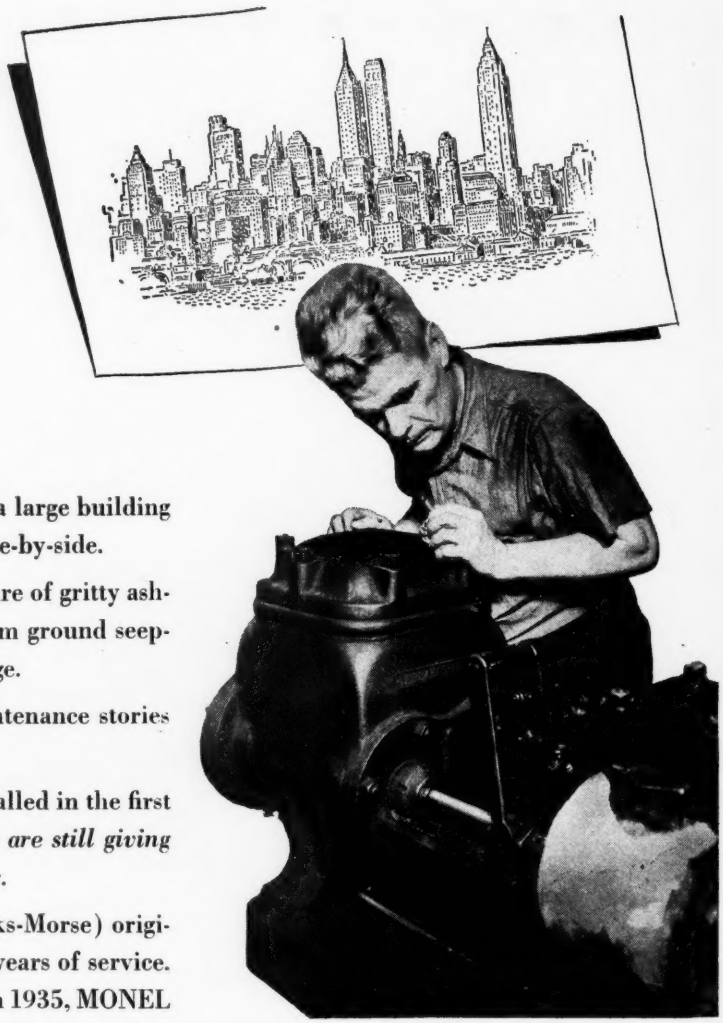
30-YEAR OLD MONEL PUMP RODS OUTLAST OTHERS 9 TO 1



Fairbanks-Morse sump pump. The 30-year old MONEL pump rods have never been replaced or reground, show very little wear, and seldom need repacking.

In the basement power plant of a large building in New York City, two pumps work side-by-side.

Both pumps handle a sump mixture of gritty ash-quenching waters, polluted waters from ground seepage, corrosive waters from coal drainage.

Identical service...but their maintenance stories are far from identical!

In 1918, MONEL* rods were installed in the first pump, a Fairbanks-Morse. These *rods are still giving perfect service today, thirty years later.*

The second pump (not a Fairbanks-Morse) originally had bronze rods. In the first ten years of service. these rods were replaced *three times.* In 1935, MONEL rods were installed. They have been giving perfect service ever since...*for thirteen years.*

The chief engineer says of the MONEL rods: "In my opinion, they will last as long as the pumps."

This is a story worth remembering next time you need pump rods, new or replacement. For when you specify MONEL, you get a "task metal"...one that is rustproof, corrosion-resistant, stronger than structural steel, hard, tough, yet readily machinable.

If your problem involves corrosion or excessive wear of working parts, why not write to Bob Johnson of INCO? He may be able to help you find a solution.

*Reg. U.S. Pat. Off.

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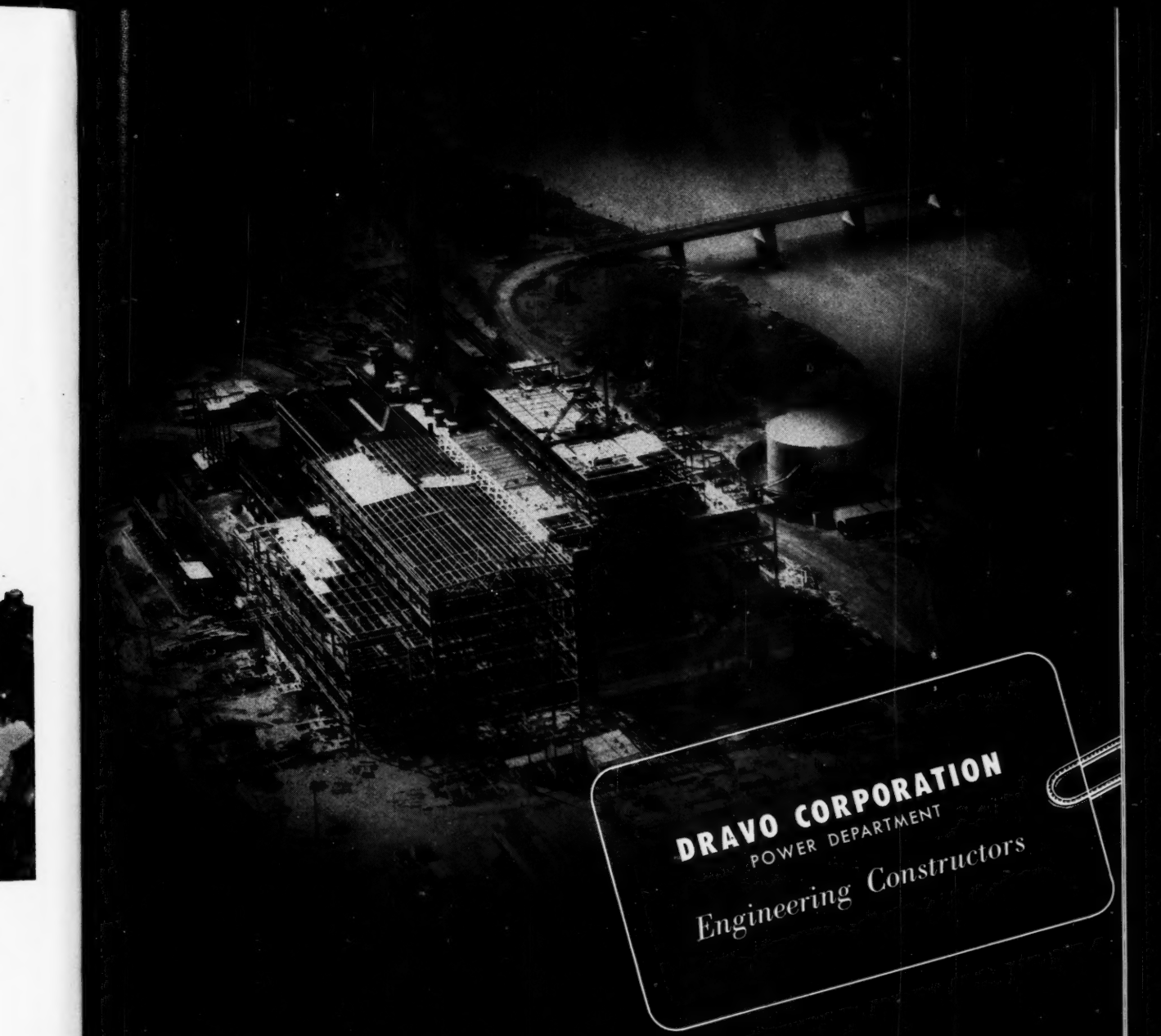

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Engineering Constructors

The PHILADELPHIA ELECTRIC COMPANY'S new 120,000 kw plant now under construction at Barbados Island, Norristown, Pennsylvania. This is one of several large central station projects now being constructed by the Power Department of Dravo Corporation.

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WATER QUALITY
is often unpredictable
EVEN IN THE MOST MODERN BOILER PLANTS

Whether your raw water is from the city supply, near-by streams, your own wells, or recovered process water, you can't control its chemical content by specification. It's the innocent looking saboteur which in its untreated or improperly treated states can clog boilers, increase steam costs, and cause overtime for boiler cleanouts. Fortunately, this bad actor can be made to work efficiently by proper treatment and careful scientific test control.

Dearborn is an organization of chemists, laboratory technicians, and water experts. Dearborn water treatment and engineering service provides means for avoiding difficulties in your plant which may be caused by water supply characteristics or variations.

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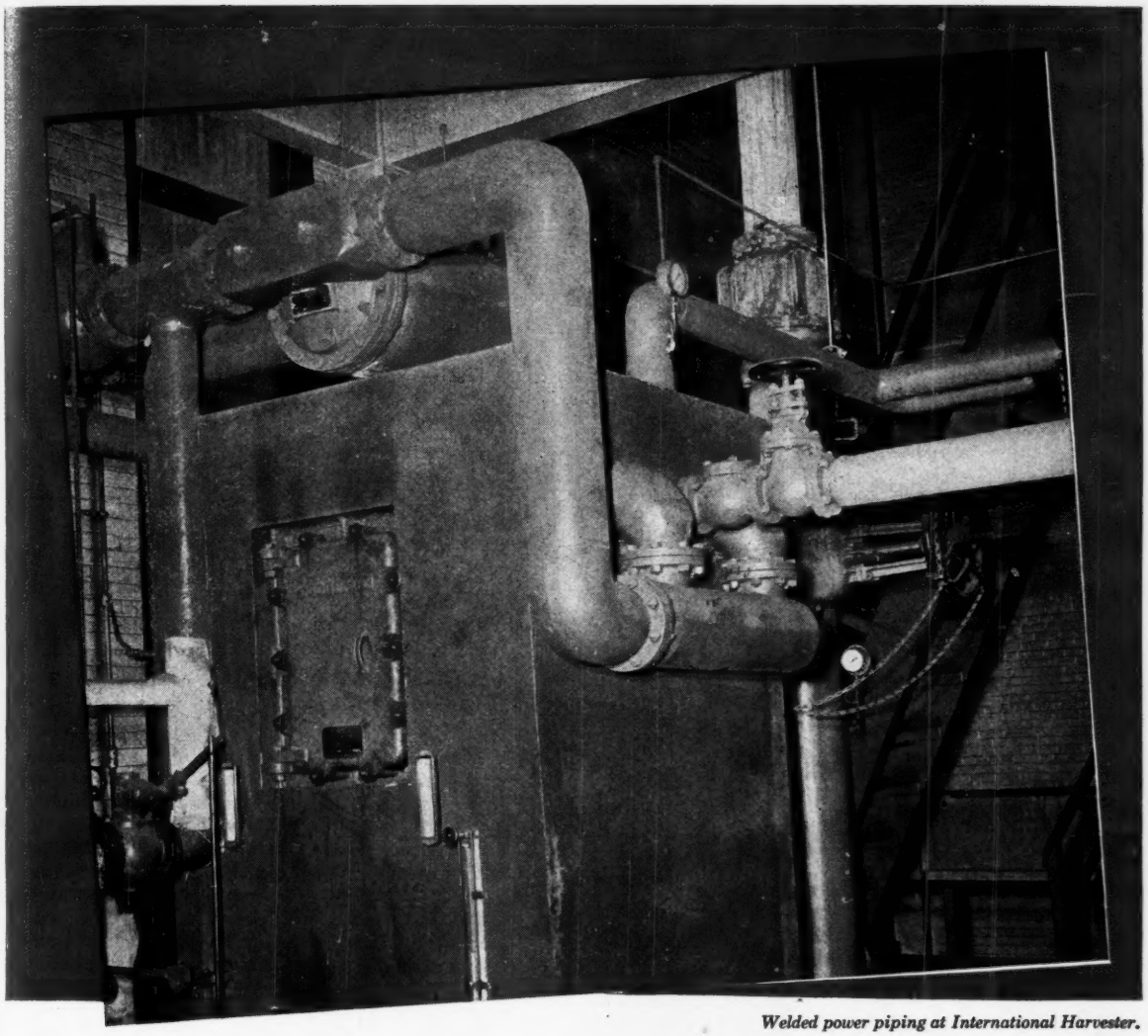

Welded power piping at International Harvester.

Piping plays a vital part . . .

IN the power plant of the International Harvester operation at Louisville, Ky., this Cochrane Deaerating Heater works smoothly and effectively with modern boilers. Thanks to Tube-Turn welding fittings, its piping system is permanently leakproof . . . a fact that assures uninterrupted service for the life of the system.

Thousands of power plants all over the country rely on the many vitally important advantages that only welded piping can provide. And, in a host of installations like that of International Harvester, Tube-Turn welding fittings and flanges are an integral part of strong, safe piping that insures years of efficient, trouble-free performance.

Behind the trade name "Tube-Turn" stands the nation's No. 1 welding fittings manufacturing experience. That's why, for good service in good connections, it pays to deal with a Tube Turns distributor.

TUBE TURNS, INC.
234 E. Broadway, Dept. E, Louisville 1, Ky.

District Offices at New York, Philadelphia, Pittsburgh, Chicago, Houston, Tulsa, San Francisco, Los Angeles

TUBE-TURN

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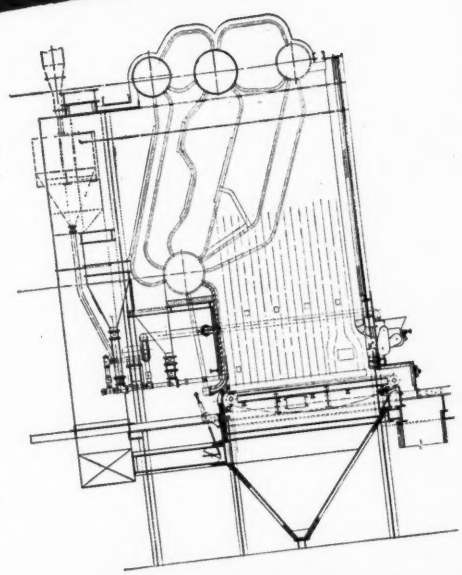
WELDING FITTINGS AND FLANGES

Write for folder, "Dimensional Data and Weights of Tube-Turn Welding Fittings." Opens to series of quick-reference tables.

Maximum Combustion Efficiency at MINIMUM COST

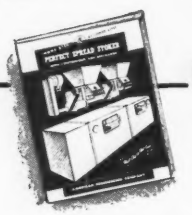


● *This installation at the Eastern plant of a national rubber company consists of an Æ Perfect Spread Stoker with Continuous Ash Discharge, with 183 sq. ft. grate area. Installed under a Babcock & Wilcox boiler with 6900 sq. ft. of heating surface, this unit is equipped with an air heater for 300° air temperature. Designed to handle increased requirements of the plant, this stoker is capable of delivering 60,000 lbs. per hour steam output using lower grades of strip coal . . . an important economy which will result in savings year after year.*

With the Æ Perfect Spread Stoker you're able to burn a wide variety of fuels—even the cheaper or lower grades of coal—and be assured of highly efficient, consistently thorough combustion.

Whether you're now hand-firing your boilers or want to replace old, inefficient equipment you'll appreciate the exclusive Æ advantages that mean completely dependable steam generation at low operating cost. Take the Continuous Ash Discharge feature for example . . . this traveling grate system provides entirely automatic removal of ash, eliminates periodic dumping of grates and cleaning of fires thus maintaining top efficiency at all times. Then too, this compact, economical stoker operates smoothly, perfectly even on wet, damp or partially frozen coal—without clogging.

Find new freedom from fuel worries and maintenance problems with an Æ Perfect Spread Stoker in *your* boiler room. Write for descriptive booklet today!



FREE—

Get this informative booklet on the Æ Perfect Spread Stoker today. Write Dept. 24.

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Æ STOKER

With Traveling, Dumping or Stationary Grates

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OTHER Æ PRODUCTS—Taylor Stokers—Lo-Hed Electric Hoists & Car Pullers—Hele-Shaw Fluid Power—Marine Deck Auxiliaries

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Merchandising over 10,000,000 tons of Quality Bituminous annually

—and you take a direct route to stepped-up boiler performance, for APEXIOR-coated tube and drum interiors give lasting new-metal service.

APEXIOR NUMBER 1 isolates steel from steam and water contact — permanently stabilizes boiler metal at new or newly cleaned efficiency beneath a surface that's insoluble in any boiler water.

Brush-applied to drums by hand, and to tubes by powercoater, APEXIOR holds the line against operating variables . . . adds a factor of security, for an APEXIORized boiler is corrosion-proof and deposit-resistant — economical to maintain because it stays insulation-free for better heat transfer, longer in-service time, less man-hour cost for cleaning.

Before you order a new boiler, or take an old one off the line, let us tell you more about APEXIORized metal. Write us at 1246 River Street, Hyde Park, Boston 36.

THE DAMPNEY COMPANY OF AMERICA
HYDE PARK, BOSTON 36, MASSACHUSETTS

APEXIOR

43-1-1

AMERICAN INDUSTRY CAN LEAD WORLD IN HUMAN RELATIONS

(Continued from page 53)

also to publish confusing statements well in advance of experimental work. Many of our new projects are likely to come more slowly and more expensively than we expected. We might better use a little more margin of safety in depending on new ideas; at least we should not spend the savings until they are realized.

In labor saving devices, industry must inevitably face the law of diminishing returns. In handling earth on excavation work we have gone from a one-ton truck to a 10-ton truck, and now to a piece of equipment with a capacity of 45 tons, but it is unlikely that we can keep on increasing capacity and economically haul in 2000 tons in a single load.

Industry of the future will require more of the engineering type of planning. A relatively complete knowledge of the engineering, economic and human relations phases of the problems will be required in an ever-changing and increasingly complicated set of conditions. Top management should have a good foundation of fundamentals, and a long and realistic contact with gradually increasing responsibilities.

It would seem to be entirely impossible for a socialized society to meet the requirements here set forth. To offset the world-trend toward socialism and communism, it behooves industry to proceed along the path which is now being followed by the best companies, and even they should make further improvements in every facet and branch of their activities as fast as possible.

Industry has certain unfinished business. Industry should better understand and diagnose its good and bad points. It is the duty of industry to keep healthy and perpetuate itself as long as it can economically render a useful service to mankind. It is incumbent upon industry to convince the public of its usefulness and integrity. Industry must first learn and then teach its employees, its customers, and the public at large, many facts about fundamental economics.

These facts involve answers to the questions:

"Can we continue to reduce working hours and add to spending hours without want?

"Can we snitch a ride going uphill, when we are supposed to do the pushing?

"Is feather-bedding honest?

"Can we find any other source of wealth than working or stealing? Can we classify all acquisitions as being one or the other?

"When will we realize that many of our ills are self-inflicted?"

Specify! "SPLIT-GLAND" Adjustable Water Gages

BRONZE OR DROP FORGED STEEL CONSTRUCTION WITH STAINLESS STEEL TRIM

Illustrates how easy Flat Glass Units are installed

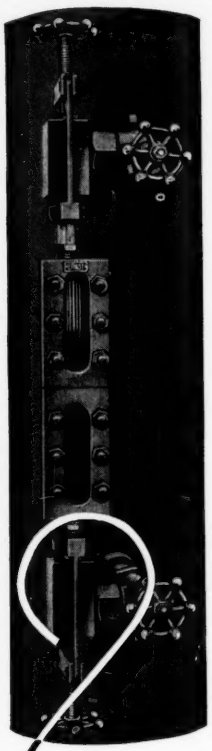
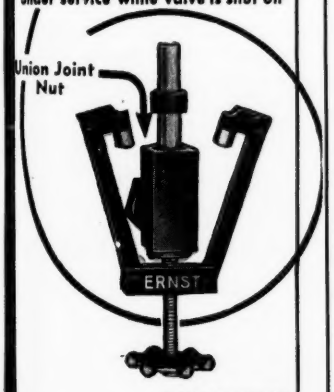


FIG. 68

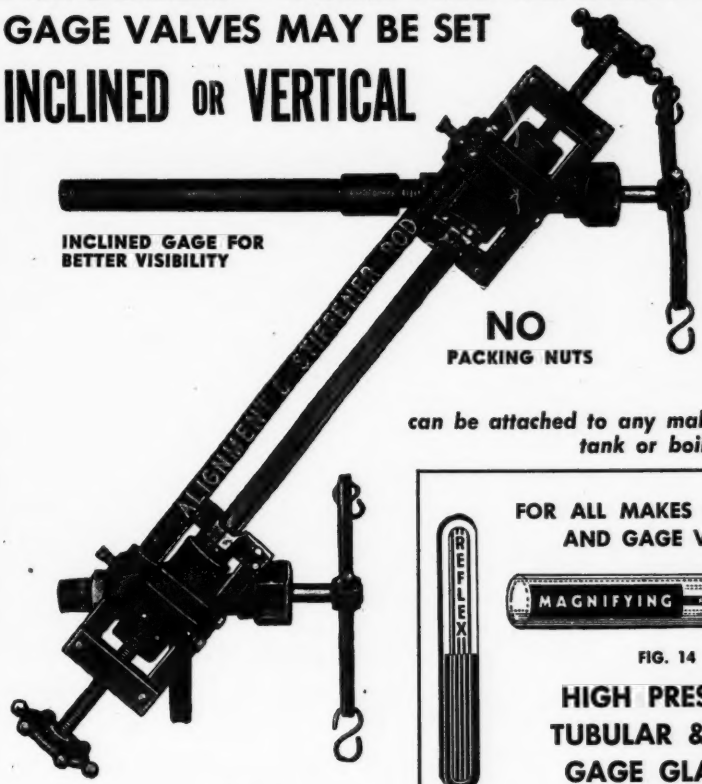
Union Joint may also be removed under service while valve is shut off



ERNST PATENTS

FOR BOILERS - TANKS AND REFINERY SERVICE etc.

GAGE VALVES MAY BE SET INCLINED OR VERTICAL



INCLINED GAGE FOR BETTER VISIBILITY

NO PACKING NUTS

FIG. 2-S

Ernst "C-Clear Thru" Inserts

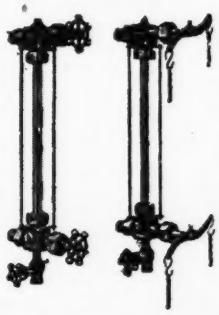
Recommended to take the place of round glasses when pressures exceed 500 lbs.

FIG. 72

can be attached to any make of water column tank or boiler.

STANDARD GAGE AND GAGE VALVES

Bronze Forged Steel All Iron Stainless Steel Construction For All Kinds of SERVICE



FOR ALL MAKES OF GAGES AND GAGE VALVES

FIG. 18 FIG. 14 FIG. 19

HIGH PRESSURE TUBULAR & FLAT GAGE GLASSES ALSO

Ernst Series 750

HIGH PRESSURE COMPOSITION RUBBER GAGE GLASS GASKETS

ANY SIZE CAN BE FURNISHED TO FIT ALL TYPES PACKING NUT BOXES AND GLASSES

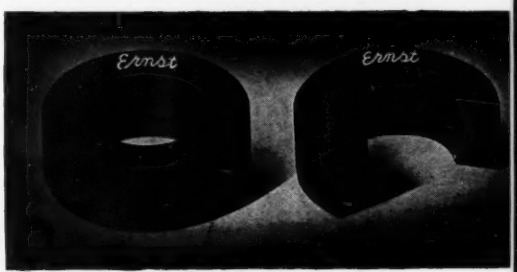


FIG. 22 STANDARD PATTERN, SERIES 750

MADE IN OVER 100 DIFFERENT STOCK SIZES

OTHER ERNST SPECIALTIES

- High and Low Alarm Columns
- Split-Gland Water Gages
- Sight Flow Indicators
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- Safety Plastic Guards
- Steel Gage Valves
- Flat Glass Inserts
- Try Cocks
- Gage Glass Illuminators
- Sight Glass and Discs
- Flat Glasses
- Tubular Glasses
- Refinery and Chemical Liquid Level Gages and Valves for All Kinds of Service, Etc.

STATE YOUR REQUIREMENTS—*Send for Catalog*

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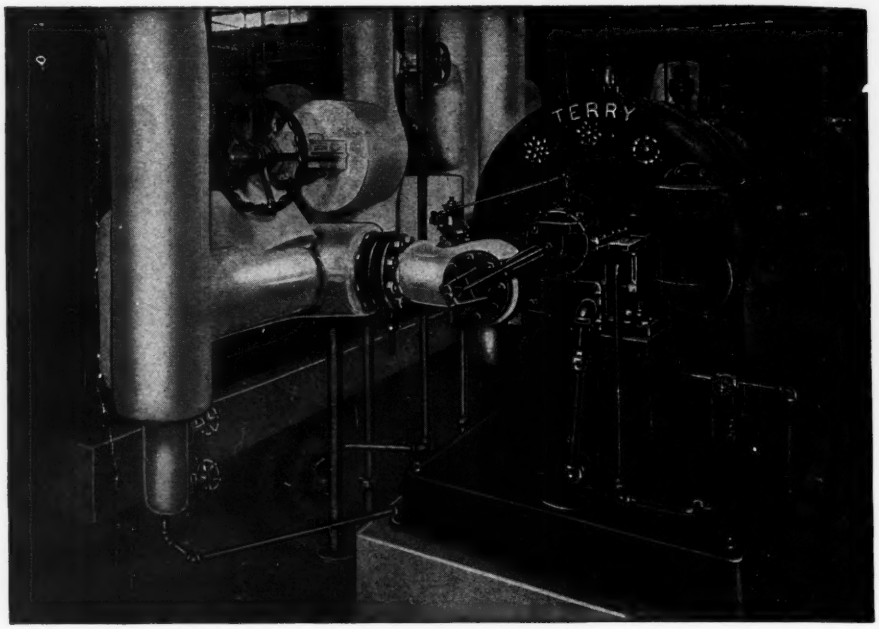
TERRY



GENEROUS BLADE CLEARANCES IN THIS 900° TERRY WHEEL TURBINE INCREASE DEPENDABILITY . . . .

The 290 H. P. Terry Turbine shown above is used for Boiler Feed Pump Drive in a recently completed central station. It operates with steam at 850 lbs.-900° F. and employs a Terry one piece wheel, as illustrated at the left.

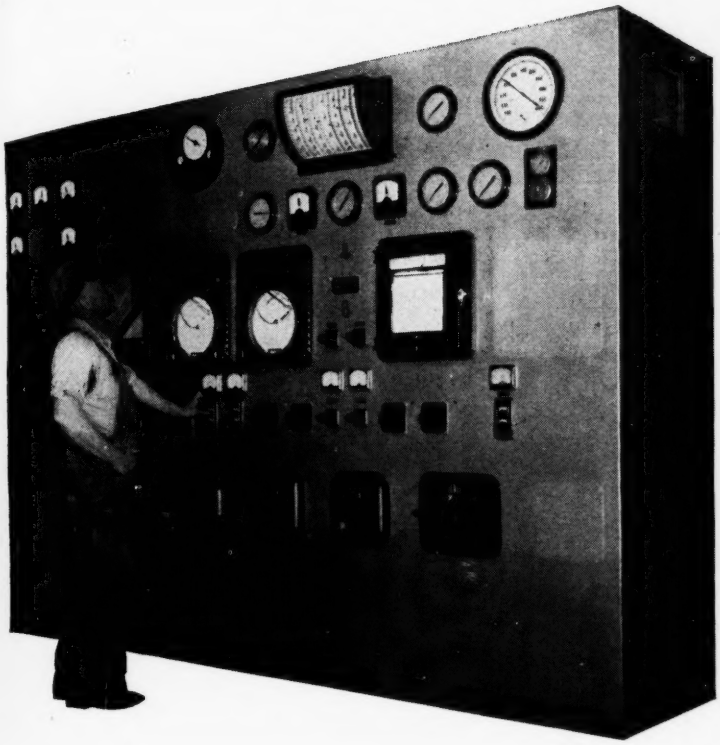
The blades of this Turbine have large radial and axial clearances. They are further protected by projecting rims at the sides of the wheel. These rims would take without damage any rubbing that might occur if the radial clearance became reduced. It is therefore impossible for the blades to foul.

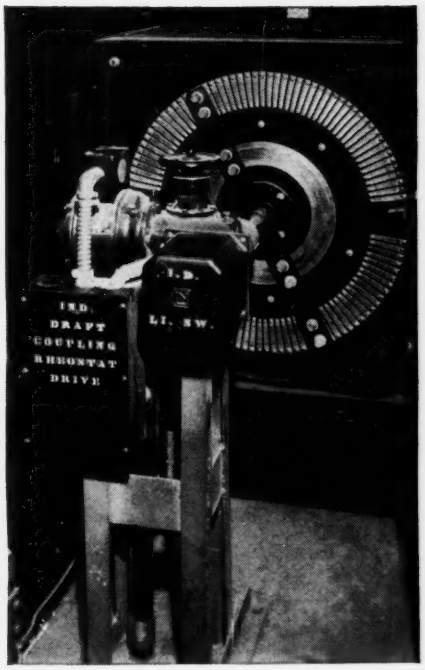
The side clearance is very large - one inch - so that end play can do no damage.

Such construction makes for dependable operation.
- Descriptive bulletins sent on request. Ask for S-116.

T-1167

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.





Metermax valve drive coupled to rheostat of a fan's magnetic coupling at Grand Ave. Station, Kansas City Power & Light Co., Kansas City, Mo.

Big Boiler Handles Load Swings Efficiently With METERMAX Controlling Combustion

Keeping the equipment that generates hundreds of thousands of pounds of high-pressure steam per hour operating at top efficiency is a job that calls for constant, accurate, highly-skilled attention.

To reduce routine operating duties, while maintaining full accuracy of regulation, Kansas City Power & Light has handed to the Metermax panel shown above the job of controlling the boiler that absorbs the load swings for their output of 1,300,000 pounds per hour.

Five other boilers carry the base load, but the 350,000 pound unit controlled by Metermax does the regulating job. And Metermax keeps it operating at top efficiency continuously.

The drive unit pictured above is just one example of the simplicity of design that contributes so much to Metermax's dependability. A small flexible coupling connects the drive unit to the rheostat that regulates exciting current to the magnetic coupling for the induced draft fan. There is no complicated mechanical linkage to give operating or maintenance difficulties.

The instruments shown here have now been in operation for several years, and the station engineers are so well satisfied with results that two more boilers will soon be operating under Metermax Control.

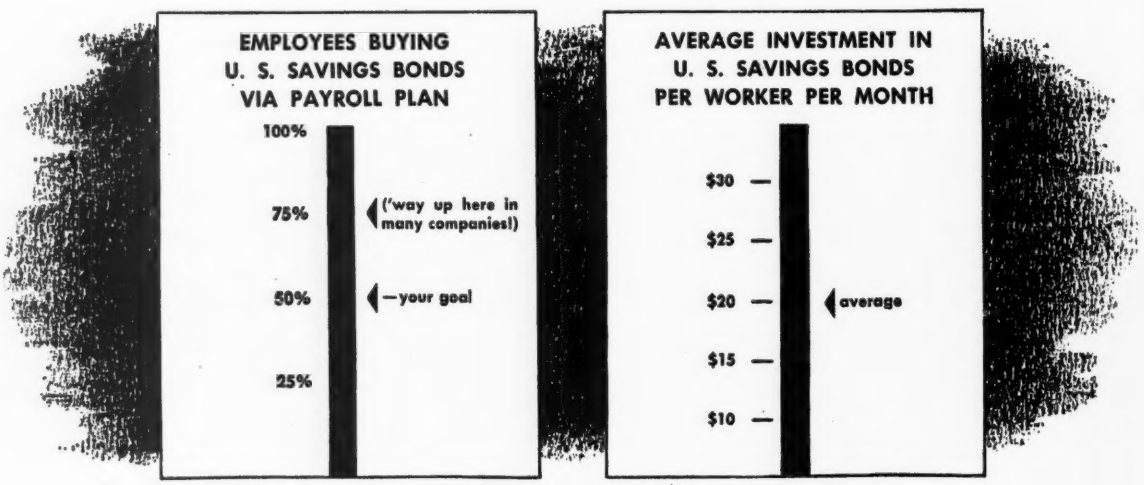
For further information, write for Catalog ND 64-01-463, or ask specific questions about the power plant you are interested in. Leeds & Northrup Co., 4973 Stenton Ave., Philadelphia 44, Pa.

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

LEEDS & NORTHRUP CO.

Jrl. Ad N-01-463(2)

How is YOUR company doing in this "EVERYBODY-BENEFITS" plan?



Compare your employee participation with others who have Payroll Savings

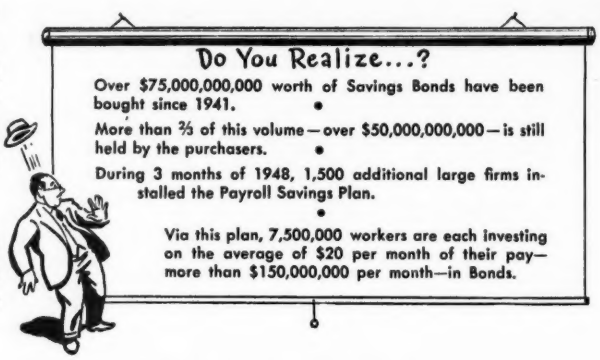
If the figures for your company fall below those shown above, you're missing your share of benefits of the Payroll Savings Plan! These benefits are described below. Nation-wide experience proves that when top management puts the "OK" on the Plan, its benefits rise sharply.

BENEFITS TO *EMPLOYEES:* Every $3 invested in Savings Bonds pay $4 at maturity. Workers gain a 33⅓% return on their money—enabling them in the future to buy more of the things they will want—plus the peace of mind that goes with regular saving.

BENEFITS TO *EMPLOYERS:* The feeling of security that goes with participation in Payroll Savings makes workers more contented. Worrying less, they work better. Among the more than 20,000 large companies with Payroll Savings, records show that—following installation of the Plan—production increased, absenteeism and accidents decreased!

BENEFITS TO THE *NATION:* The Payroll Savings Plan is a powerful deterrent to inflationary forces. Every Savings Bond dollar built up in the Treasury withdraws a dollar from the swollen spending stream. The Plan thus contributes to national security—which affects *your* security!

WHAT CAN *YOU* DO? If your company has the Payroll Savings Plan, make sure it's being adequately promoted—backed by your top executives—to bring your company its full measure of benefits. If you haven't yet installed the Plan, why pass up its benefits any longer? All the help you need is available from your State Director, Savings Bonds Division, U. S. Treasury Department. He is listed in your telephone book. Call him now!

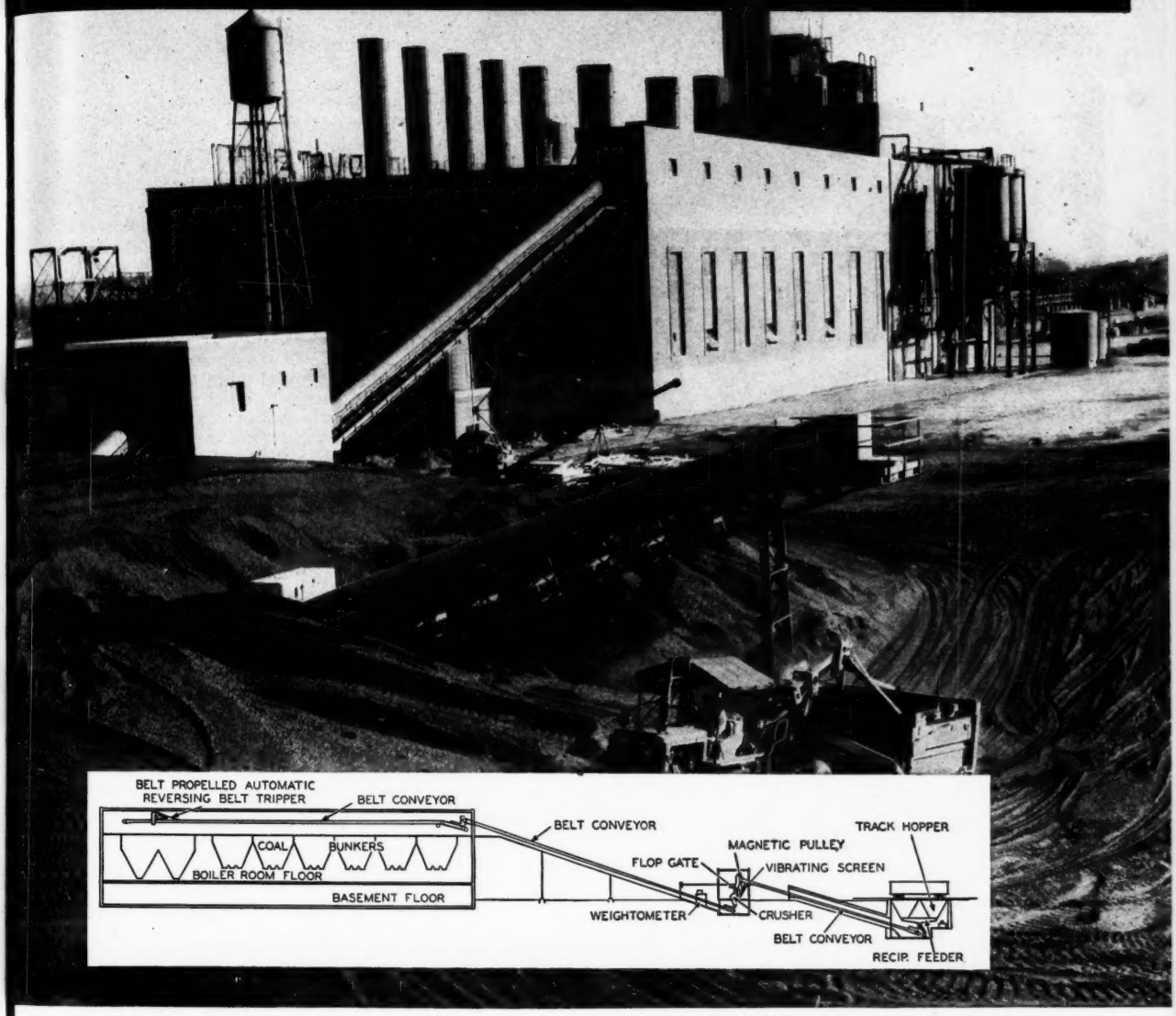

Do You Realize...?
Over $75,000,000,000 worth of Savings Bonds have been bought since 1941.
More than ⅔ of this volume—over $50,000,000,000—is still held by the purchasers.
During 3 months of 1948, 1,500 additional large firms installed the Payroll Savings Plan.
Via this plan, 7,500,000 workers are each investing on the average of $20 per month of their pay—more than $150,000,000 per month—in Bonds.

The Treasury Department acknowledges with appreciation the publication of this message by

POWER GENERATION

This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and the Advertising Council.

Tulsa Power Station Served by Link-Belt
Integrated Coal Handling System



High Efficiency, Capacity at Lowest Handling Cost

The diagram above shows how a Link-Belt integrated conveying system handles 150 tons of coal per hour at the new Tulsa, Oklahoma, power station (Sargent & Lundy, Chicago, consulting engineers).

Coal is dumped from railroad cars into hoppers equipped with double reciprocating feeders, which deliver it to an inclined belt conveyor. This belt passes over a magnetic pulley for removing tramp iron, and the coal then passes over a vibrating screen which separates the metal from whatever coal might be with it. The coal is crushed to 3¼" by 0" and delivered to the long belt conveyor which carries it to the bunkers above the boiler room. From the bunkers the coal is fed to pulverizers and blown into the boilers. The plant has an added capacity of 25,000 KW.

The list of generating plants with coal handling systems by Link-Belt is impressive. Why not apply Link-Belt "know-how" and products to your own problem?

TYPES OF LINK-BELT CONVEYING MACHINERY

Belt Conveyors	Bulk-Flo Conveyors
Bucket Carriers	Screw Conveyors
Bucket Elevators	Car Unloaders
Flight Conveyors	Coal Crushers
Chain Conveyors	Weigh Larries
Apron Conveyors	Skip Hoists

LINK-BELT COMPANY Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices in Principal Cities.

11,362

LINK-BELT

CONVEYING MACHINERY
"THE COMPLETE LINE"

No other tube cleaner could do it!

★ The engineer of an upstate New York university power plant with five large boilers tried every known make of tube cleaner, including our old Roto. He didn't think any of them "worth a hoot" for removing his rock-like scale.

★ When we developed the new ROTOJET, we sent him our Model 525 for field test. He was so amazed and tickled with the way this powerful new cleaner performed that he insisted on buying it. He said it was the first cleaner that ever cleaned his tubes properly, and that "it made a tough job seem ridiculously easy."

★ No tube cleaner built during our 38 years of specialization in this field can even remotely compare with the new ROTOJET for power, efficiency, and cleaning speed. A single cleaning job with a ROTOJET will prove that you can't afford to use any other tube cleaner.

Send for new bulletin

ELLIOTT COMPANY-ROTO DIVISION

147 Sussex Avenue Newark 1, N. Y.

O. H. HUTCHINGS STATION

(Continued from page 57)

bunker has a capacity of 600-tons per boiler and is maintained under slight suction for dust control. Coal is fed by means of two coal chutes to a coal scale, and thence to the pulverizing mills and burners, Fig. 1.

Ash from the dry-bottom furnace falls into a water-filled pit from which it is sluiced to an ash sump. A hydraulic vacuum system removes fly ash from the dust collectors, superheater hoppers and from the base of the stack. All ash is pumped from the sump to an old gravel pit adjacent to the station, Fig. 6, and when that is filled it will be pumped to a second gravel pit 500 ft away. The latter pit yielded the aggregates used in station construction.

Electrical System

The 12,500-v output of the generator is stepped up by transformers, in the new substation erected adjacent to the station, to 66,000 v for transmission over four circuits to the present 66,000-v transmission ring. Each circuit is provided with fault-bus protection and high-speed carrier pilot relays. Oil circuit breakers of 2,500,000 kva interrupting capacity were provided for switching.

The normal station auxiliary power supply is through a 6,000-kva, 12,500-v-to-2300 v unit transformer. An alternate supply is provided using a 7500-kva, 66,000-v-to-2300-v station transformer. Both transformers are located out of doors.

Operation

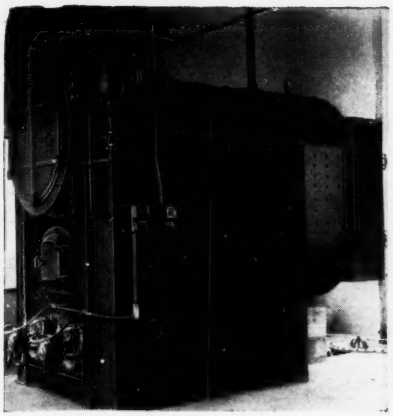
Manpower requirements of the station are at a minimum consistent with efficient and safe operations. Mechanical control is from a control room, staffed by two experienced operators per shift, who perform all essential operations within the control room except starting of the turbine and operating the circulating pumps, screens and ash removal system. An auxiliary operator and one apprentice operator outside the control room, complement the two control room operators and these four men can operate two units.

One electrical switchboard room, overlooking the turbine room, will serve all six units. It is manned by one switchboard operator per shift. A shift engineer for the entire station rounds out the number of men required for operation.

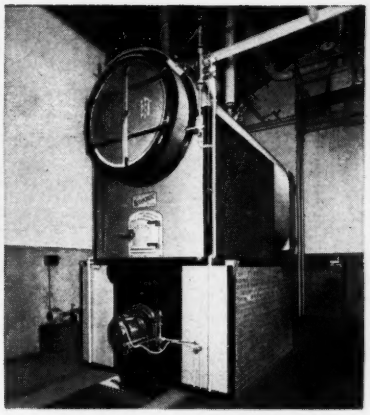
SOLVENT CLEANING

(Continued from page 61)

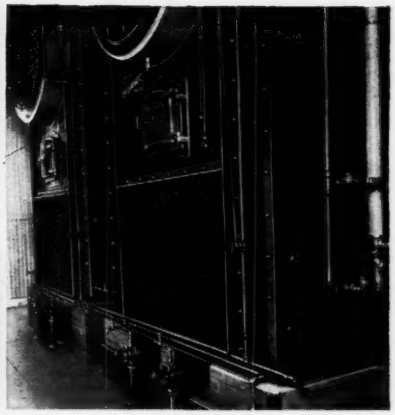
phate or carbonate present in the deposit to bring about a condition approaching disintegration. It is then quite possible to wash away the sandy, still slightly bonded, deposit. But 24 to 36 hr of soaking with water at temperatures close to 180 F may be required, followed by the use of a small-diameter, high pressure



• 80 HP. ECONOMIC with extended sides providing furnace volume for oil firing.



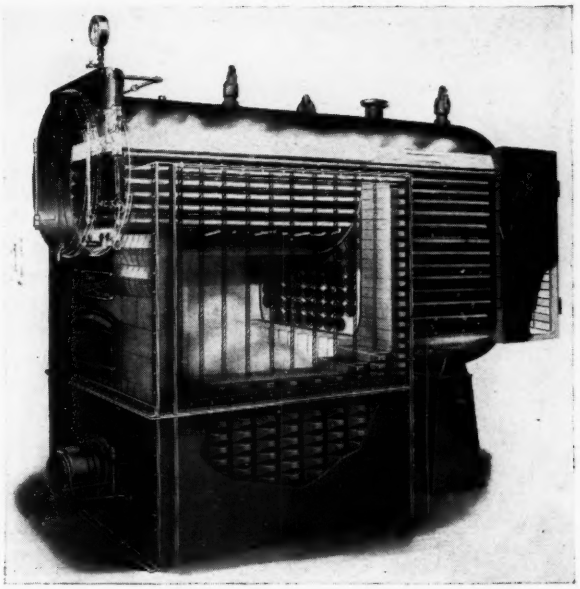
• 150 HP. ECONOMIC with brick base built-up in the field to provide furnace volume for oil firing.



• 2-150 HP. ECONOMICS with extended sides providing furnace volume for oil firing.

THE ECONOMIC BOILER For OIL or GAS Firing

HUNDREDS of Economics—the boiler refractory lined furnace combination, are gas or oil fired. The furnace volume required with these fuels is provided either by building a brick base in the field, by increasing boiler height (watch railroad clearances) or by the use of the new Erie City Steel Base completely shop fabricated with 13 1/2" refractory lining. This last method eliminates costly brickwork in the field and permits shipment of any standard size of Economic to 300 hp. as one unit and base as a separate unit. This economical steel base can be furnished in heights from 2 to 6 feet and provides a sturdy long life foundation that becomes an efficient addition to furnace volume.



• ERIE CITY'S NEW HIGH REFRACTORY LINED BASE eliminates costly brickwork in the field, speeds the erection of the boiler, and provides the extra furnace volume required for oil, gas, or stoker firing.

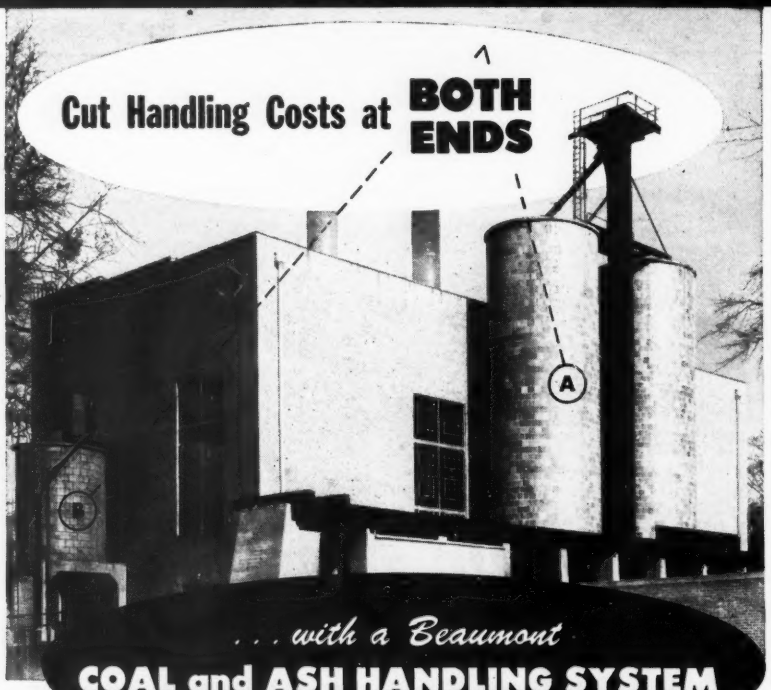
The refractory lining of the steel base is the same as used in the well known Economic. It consists of 9" of first grade refractory and 4½" of block insulation or 13½" of refractory depending upon conditions. The weight of the boiler rests on the steel base not on the refractory.

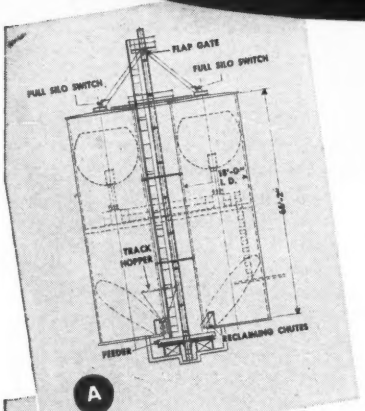
COMPLETE STEAM POWER PLANT EQUIPMENT

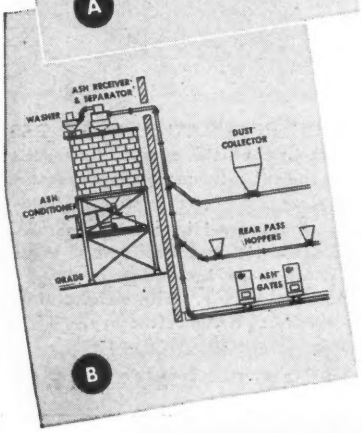
ERIE CITY

Complete Steam Generators • Type C 3-Drum Boilers • Type VL 2-Drum Boilers • The "Economic" Boiler with or without Water Walls • Welded H. R. T. Boilers • Welded Steel Heating Boilers • Coal Pulverizers • Underfeed Stokers • Welded Pressure Vessels for the Process Industries.

ERIE CITY IRON WORKS • ERIE, PA. • *Since 1840*







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ASH REMOVAL

The Beaumont "Vac-Veyor" system offers the most direct and economical method for removal of ashes, siftings, soot and dust. They are vacuum conveyed through a pipe from their source to an ash receiver and separator—then into the silo where they remain until final disposal.

Beaumont engineers design and erect this equipment—a complete coal and ash handling system. This brings you savings in installation as well as in handling costs—you have one contract, we have sole responsibility.

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Designers Manufacturers Erecters BULK MATERIAL HANDLING SYSTEM

stream of warm water applied from the top and sides, working downward.

In rare cases, a weak acid solution may be prescribed.

In another field of extended surface element, an alkaline wash water is used occasionally. It is the application of waste heat boilers for heating by SO_3 gas. (See Fig. 11) Sulphuric acid manufacture often involves burning liquefied sulphur in a combustion chamber and cooling the SO_2 to a controlled temperature by passage through an armored surface, water tube boiler. Air is added while the SO_2 is in a catalyst-filled vessel and the SO_3, now at higher temperature due to the exothermic reaction, is passed through another waste heat boiler, or an economizer. If the air added to the SO_2 is not thoroughly dry, or if steam or water should somehow enter the gas stream, sulphates form and heavily coat the SO_3 cooling surface.

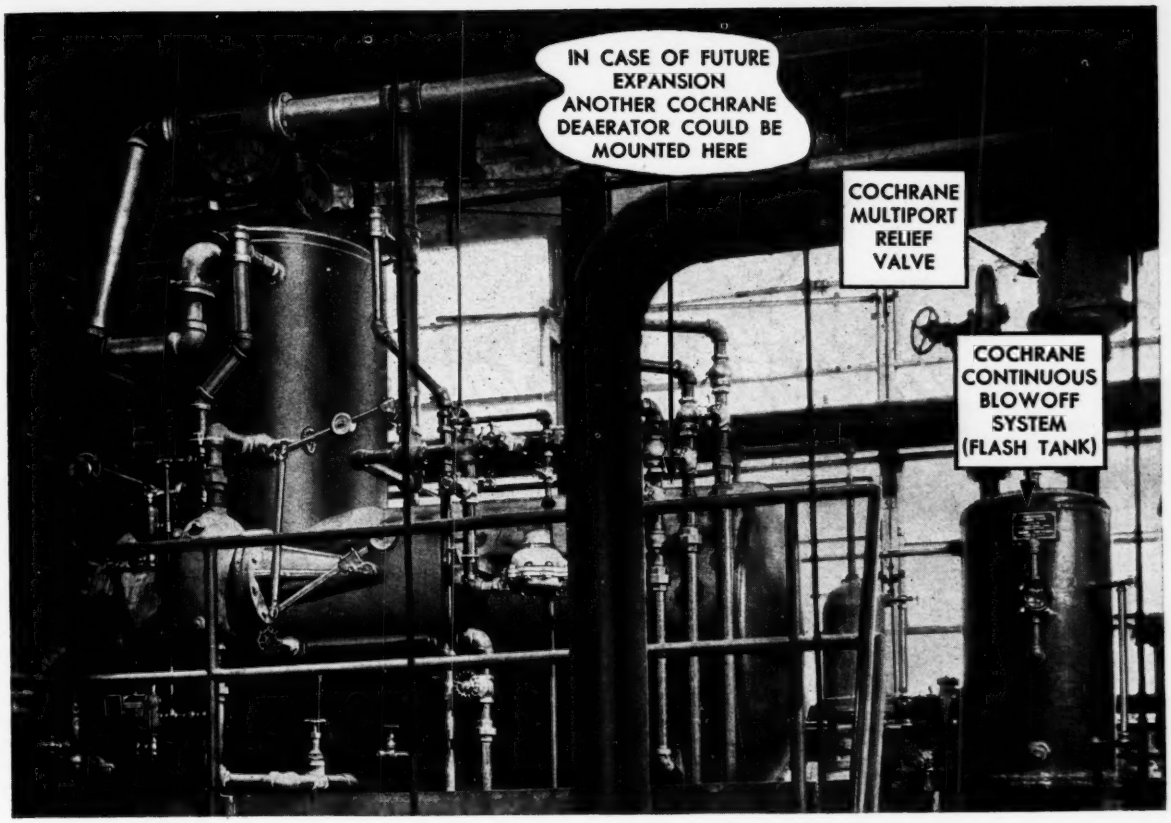
Soda ash and caustic soda may be mixed with warm water to make a "50 per cent alkalinity" solution for washing surfaces, using the spray technique already described. The arrangement is somewhat different in order to permit alkali re-inforcement as cleaning progresses. (See Fig. 11) Dilution and "side stream" drain off is adjusted to minimize high concentration of solids in spray water. When the sulphates begin to fall from element surfaces as "mud," the stream from a hose is applied, after the manner outlined above. Sludge may be shoveled out of the steel-lined catch basin from time to time.

The washing of air heaters is common with certain types. In the case of the regenerative design, water is sprayed into the revolving mass of heating surface plates. Rapid drying of the surface reduces corrosion hazards, but the washing must be done before deposits reach proportions that block the passages.

A generally satisfactory technique for the solvent cleaning of tubular or plate type air heaters has not been developed. Heating surfaces are thin and the mechanical arrangements seldom offer an easy application of the "water washing" principle.

Removal of adherent coatings from the exterior of boiler tubes by vaporized HC1 solutions has been reported. Technique, limitations and efficiency are unknown to the writer, and have not been developed to a standard practice. Satisfactory cleaning of exterior surfaces by this, or a similar method, would reduce, if not eliminate, one definite restriction to the wider use of the compact surface arrangements, now otherwise practicable, with forced circulation design and solvent interior cleaning.

Strong desire to use such designs may develop quickly after a period of experience with all-welded construction, internal scale solvents, and the first, large, pumped-circulation boilers. Experience with the burn-


IN CASE OF FUTURE EXPANSION ANOTHER COCHRANE DEAERATOR COULD BE MOUNTED HERE
COCHRANE MULTIPORT RELIEF VALVE
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COCHRANE DEAERATORS

ALSO FIT THE SMALL PLANT AND LEND THEMSELVES TO

FUTURE EXPANSION

Above is shown a neat installation of a Cochrane deaerator and other boiler plant equipment in a plant where space requirements are limited. The installation on a balcony not only provides adequate room for inspection and servicing but is laid out with an eye to future expansion.

The 30,000 lb/hr. Cochrane deaerator, in a rolled steel cylindrical shell, is mounted at one end of a 9′ 3″ x 4′ 0″ diameter rolled steel horizontal cylindrical storage tank. Another deaerator of similar capacity may be mounted on the other end in case of future expansion of the boiler plant.

This progressive plant not only thus insures protection against rust and corrosion of piping, economizers, etc., by the Cochrane Deaerator but is saving fuel and saving heat by the installation of a Cochrane Continuous Blowoff System instead of using the old, wasteful system of intermittent boiler blow down. The Cochrane Multiport Relief Valve shown is another Cochrane product that insures efficient operation by eliminating danger of sticking, jamming or freezing, by its unique design of many valve discs instead of one.

Cochrane equipment is designed for the economical, efficient and safe operation of boiler plants. Write for bulletins on any of these products. Cochrane Corporation, 3123 N. 17th St., Phila. 32, Pa.

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ing of oil and gas in combustion chambers under pressures of 50 psi or more, is accumulating through the use of the Houdry oil refining cycle gas turbines over the past ten years. There are foreign marine installations using similar furnace pressures. Sufficient gas pressure remains after leaving the boiler, to operate the gas turbine that drives the compressor which delivers the necessary combustion air to provide the furnace pressure. The U. S. Navy regularly uses a furnace pressure of 2 psi. It is possible that as increasingly compact boiler tube arrangements develop, the exterior cleaning problem may, itself, disappear. Water is used by the U. S. Navy to clean the exterior of the small, closely spaced tube assemblies in its marine steam generators, such as shown in Fig. 12.

TANKAGE AND OPERATING AIR PRESSURE

(Continued from page 63)

psig system, considering that this compressor actually operates loaded 58 per cent of the time, and using a power demand of 3 bhp for the unloaded portion of the time, is approximately 113,000 kwhr per year. For the 100-psig system, the loaded operation represents 62½ per cent of the time, and its consumption is approximately 137,750 kwhr-per year. The difference of 24,750 kwhr per year represents an increase of about 22 per cent over the energy used by the 70-psig system, and might be a factor under conditions of high energy cost. In central station practice it would not be of great consequence.

With these facts in mind, each integrated control system should therefore be reviewed to determine that the storage volume and nominal operating pressure are chosen to suit the requirements for effective operating time after compressor failure, duty on the compressor unit, and power consumption.

SELECTING POWER CABLES

(Continued from page 67)

cycle) plus circuit breaker time (8 cycles) = 8.5 cycles.

Total rms current affecting cable heating = $K_1 \times 20{,}800 = 1.1 \times 20{,}800 = 22{,}900$ amp.

From the large chart on Fig. 1 the intersect of the 22,900-amp horizontal line and the No. 2/0-Awg cable conductor line indicates only 6 cycles permissible duration (75 - 150 C basis) which is obviously inadequate.

Using the procedure detailed in Example 3, it will be found that a No. 3/0 Awg conductor (210-amp rating) operating at 175 amp would run at approximately 61 C total temperature.

Following across the 22,900-amp

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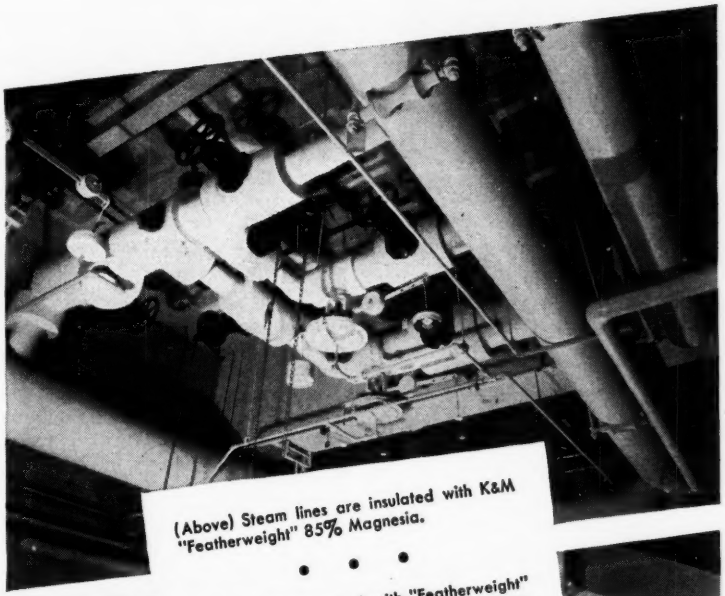

(Above) Steam lines are insulated with K&M "Featherweight" 85% Magnesia.

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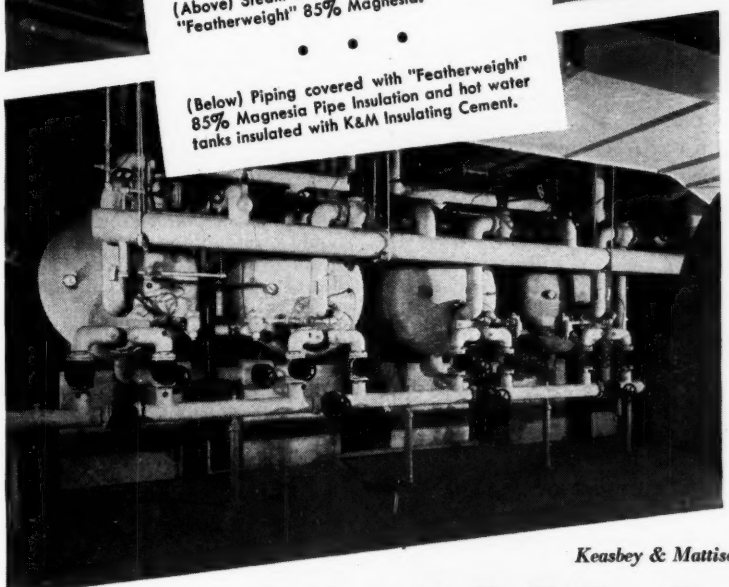

(Below) Piping covered with "Featherweight" 85% Magnesia Pipe Insulation and hot water tanks insulated with K&M Insulating Cement.

This imposing home office of the New England Mutual Life Insurance Company, Boston, is supplied with heat from a central heating plant.

The steam pipes are insulated with K&M "Featherweight" 85% Magnesia with the net result that heat losses are reduced to a minimum.

"Featherweight" 85% Magnesia insulation, first manufactured by K&M 62 years ago, combines the high insulating properties of basic Carbonate of Magnesia with Asbestos Fibre as a binding agent, forming a featherlight, fireproof, efficient insulating material.

K&M Distributors, located strategically throughout the country, are experts on the application of K&M insulation materials . . . and can point the way to savings for you. Write us for further information.

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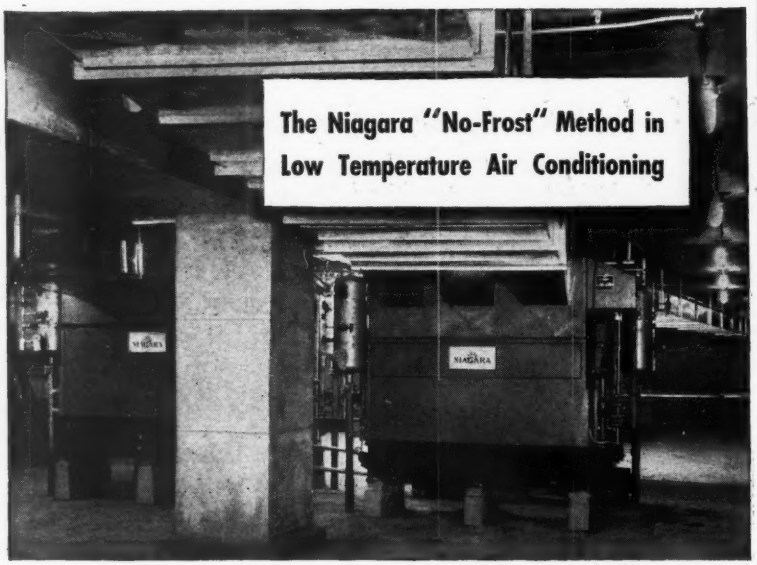

High Precision Industrial Air Conditioning with extremely dry atmospheres (or with high relative humidities) at low temperatures.

● Specializing for thirty years in the more difficult problems of air conditioning for industrial processes, this Company has developed a group of units that make it easier and less expensive for you to get the particular air conditioning benefits you may need for your special process, or to overcome some obstacle of climate or condition that is interrupting your production or causing loss from rejected parts or materials.

The Niagara "No-Frost" Method, for example, has been used to create temperatures as low as -90° F. in cold test rooms, and to provide air with only 1 gr. of moisture per lb. for special processing.

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Some of the industrial applications of these units: internal combustion engines, motors and air craft, super-chargers and carburetors, gas cooling and controlled atmosphere process, film, plastics, fiber, rubber and adhesives control, biological processing such as penicillin, and yeast.

Write for a Niagara Blower Bulletin on a subject which interests you, or for the address of the nearest Niagara Field Engineer.

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line it will be noted that a No. 3/0-Awg conductor will permit a time of 8.5 cycles (75 - 150 C basis).

For a temperature range of 61 - 120 C the correction factor K = 0.83 (See detail chart B).

The permissible time for a No. 3/0-Awg conductor (61-120C basis) will be $K_1 \times 8.5$ cycles $= 0.83 \times 8.5$ cycles—7 cycles which is inadequate.

Repeating this procedure based on a No. 4/0-Awg conductor (236-amp rating) discloses permissible time of 12½ cycles at 22,900 amp which is adequate.

A check should be made at a current just below the operating current of the instantaneous relay element. At 1750 amp, permissible time is in excess of 20 seconds which is more than adequate.

Thus a No. 3/0 Awg conductor represents the correct selection.

RESERVE COAL STORAGE

(Continued from page 72)

dust explosion hazard in installations where the coal is dry and dusty. This hazard may exist in enclosed spaces such as conveyor tunnels or galleries, elevator casings, houses where crushers and pulverizers are operating, and in the monitor above a bunker. If the conditions are right, which means a suitable mixture of dust with air and a source of ignition such as a static spark, a spark from a fragment of steel, an open flame, or an open switch, such an explosion may be disastrous in its violence. Figure 5 shows an explosion of 200 lb of coal dust in the Bureau of Mines experimental mine near Pittsburgh.

Fortunately a coal dust explosion can occur only when the percentage of dust in the air is between an upper and lower limit. With minus 200-mesh Pittsburgh coal, for example, the limits lie between 0.032 and 0.08 oz per cu ft of air. Usually the limit will be not far from 0.05 ounce per bu ft. Such a condition or saturation cannot exist throughout a room or gallery, but if a puff should occur in a crusher hopper or within a Bradford breaker, or in a chute, it may dislodge accumulations on machinery supports, ceiling beams, and the like, and provide the conditions which will transmit the flame or initiate a detonation. Ventilation and good housekeeping are worth while.

Monsanto Chemical Co. announced recently that J. P. Bufe is the new head of the power division at its Monsanto, Ill. plant. The change becomes effective early in February, when H. A. Dilliard, whom he replaces, will resign. Bufe's new duties, in addition to direct supervision of the power house, will include the services of air, water, steam and electricity.

AT THE NEW YORK POWER SHOW

Hope you didn't miss seeing the exhibit of American Blower Type VS Gyrol Fluid Drives for Boiler Feed Pumps and—

Type TM Gyrol Fluid Drive, the packaged Hydraulic Electric Power Unit for smooth power in industry.

If you did not get to the show, ask the nearest American Blower Branch Office for your copy of Bulletin No. 8519 on Type TM Gyrol Fluid Drives or Bulletin No. 8019 on Type VS Gyrol Fluid Drives for Boiler Feed Pumps.

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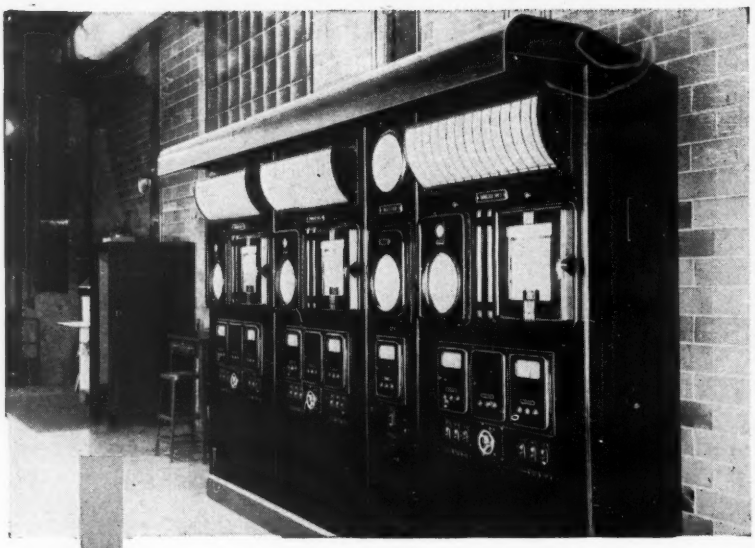

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QUICKLY PAID FOR ITSELF

How to get more steam to meet the demands of steadily increasing production, with all three boilers in continuous operation: that was the problem at General Mills' plant in Paris, Illinois.

A Hays Automatic Combustion Control System with full instrumentation was installed—and the problem ceased to exist. Production went up sharply from 12,500 bushels per day using three boilers, to 22,500 bushels per day using only two boilers—with the third for standby. Combustion is smokeless, velocity of gases was reduced, operating pressure is higher and turbine steam consumption dropped 1000 pounds per hour. CO_2 averages 15 percent as against the previous 7 percent; boiler efficiency rose from 55 to 78½ percent. Steam costs dropped sharply. The Hays system quickly paid for itself.

Records like this of Hays performance are not exceptional; and indicate that it's good business to *find out* about this modern electrical system, to investigate *what it will accomplish for you* in improved production and lower costs.

Talk over your plant's steam requirements with a Hays engineer—no obligation, of course. And write for Publication 47-605: worth reading.

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INDUSTRIAL INSTRUMENTS · INDUSTRIAL CONTROL · FLOWMETERS · GAS ANALYZERS · DRAFT GAGES · CO_2 RECORDERS

SIMPLIFYING BOILER DESIGN

(Continued from page 77)

elements in air are not a chemical mixture and are of different molecular weight. Or by a cheap method of absorption and then liberation perhaps by the use of a catalyst that can be revived. Or by breaking up water into O_2 and H_2 and then using the remaining hydrogen as fuel, by some cheaper method not already hit on, as water is very plentiful. Anyway it's an interesting problem to keep our best engineers and scientists entertained.[1]

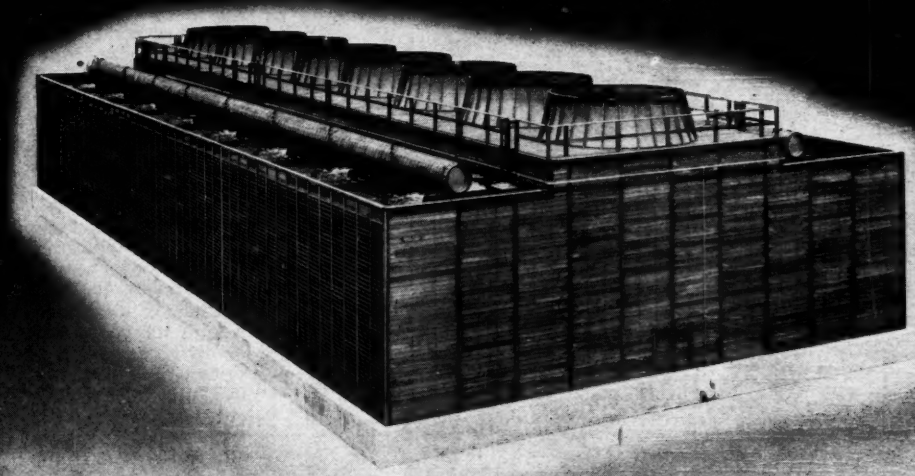
Pure oxygen for combustion is the vivid dream of combustion engineers and a great deal of research on it is being done at the present time.

The writer contends that the steam generator of the future will have practically no convection boiler surface and that used will tend toward extended surface area. The units will be completely water-cooled furnaces with the ultimate of radiant heat absorbing surfaces. The superheaters, convection and radiant, and boiler water preheaters plus air heaters will all be designed for highest possible air preheat temperature—500 F or higher. Also, in time, there should be a swing toward "once through forced circulation because of simplicity, compactness, saving in material and cost, making possible prefabrication in the shop and shipping to the job either complete units or partially assembled parts that will be simple to erect in the field. I believe our engineers will become more conscious of the outstanding features of "once through" forced circulation, particularly where high pressures are warranted and a cycle can be worked out so that the primary boiler circuit can be intact. This would be fundamentally on back pressure turbine installations with the exhaust steam being condensed above atmospheric level in a steam transformer or steam heated boiler to supply required process steam as a secondary cycle.

In this connection refer to Fig. 3 which shows a typical assumed cycle diagram. In this case 100,000 lb of steam per hr is produced for process at 175 psig and 450 F level, giving 82 F of superheat, from 116,674 lb per hr of 225 psig steam at 500 F level. Five per cent is blown down from the process water supplied from the low pressure water treatment plant and deaerating heater. Steam for the deaerating heater is supplied from station auxiliaries such as high pressure feed pumps, low pressure feed pumps and possibly forced draft boiler blower sufficient to give 0.000 oxygen feedwater at 249 F temperature from the 10 psig exhaust pressure. 3780 kw can

[1]See How the New Elliott Oxygen System Works. Power Generation, December 1948. Page 104.

Specify MARLEY Double-Flow



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Marley Double-Flow Cooling Towers have an Open Distribution System.

And why is that important?

Because the Marley Open Distribution System is . . .

EASY TO INSPECT . . . it's on top of the tower, in broad daylight, never hidden from view.

EASY TO REGULATE . . . a widely varying GPM may be circulated over the tower without revamping the distribution system.

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UNUSUALLY SAFE . . . no climbing through small portholes, across slippery members . . . no danger of falling through the filling while crawling about in narrow spaces in semi-darkness while inspecting or cleaning.

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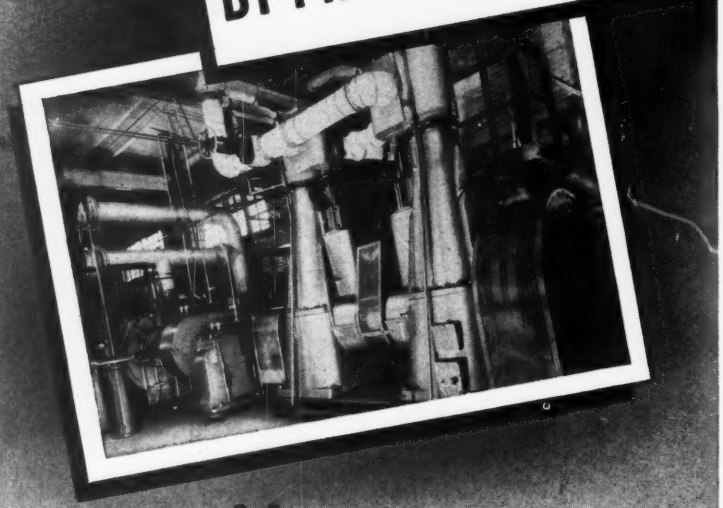

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Use boiler steam to run a Troy-Engberg Steam Engine. THEN use the exhaust in your heating or processing lines. Drive your pumps, stokers, generators, blowers or compressors with By-Product Power. Use a Troy-Engberg Steam Engine as a reducing valve and your power cost saving will pay for the engine in a very short time.

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be generated from the initial 116,380 lb of steam per hr at 850 psig and 850 F (900 psig boiler pressure) down to 225 psig and 500 F level back pressure where it is condensed in producing plant process steam as described above.

This makes possbile the simplest boiler water treatment plant offsetting the cost of the steam transformers as the temperature in the steam transformers will be low, limiting scale formation, and a multiplicity of steam transformer units, say 3, can be used so that 2 are in service and one down for cleaning. Vertical straight tube type steam transformers (Fig. 4) with the independent tube bundle spaced out from the side to give excellent circulation can be used, which, incidentally, can be designed as indicated for reasonable superheat dependent on the entering steam temperature. Inasmuch as the primary or clean side is on the outside of the tubes and the secondary or dirty circulation path on the inside, it is very easy to clean just by entering the top manhole and either turbining or brushing the interior tube surface. Also, the design allows the maximum flexibility for expansion and contraction of the heated parts. Everything is suspended.

"Once through" forced circulation, again I state, makes possible variable pressure operation very simple. It is only necessary to vary the feed pump pressure which can be done almost simultaneously with positioning of the speed change governor on the main turbine. This will attain the maximum turbine efficiency under all load conditions. If for some reason the turbine should be taken out of service and it is still desired to produce process steam and continue to maintain high pressure steam on the boiler, a steady back pressure exhaust level can be held by means of a "by pass" pressure reducing and desuperheating station connected between the boiler and exhaust headers. Or the boiler pressure can be lowered and the steam fed to the required back pressure exhaust level for process steam production by means of proper valving and steam line arrangement by passed around the turbine. With the turbine in service on variable pressure operation, no reducing station will be required all the steam used will produce work.

As an illustration of another cycle utilizing all evaporated feed water for the high pressure boiler, see Fig. 5. This involves a high pressure non-condensing turbine placed on top of an existing extraction condensing plant which was built for 450 psig and 650 F using 1- 1500 kw and 1- 1000 kw turbine generator. A quadruple-effect steam transformer or evaporator system is used. The steam transformers are similar to the units for the other cycle ex-

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That's why, when you require wide-open, full-pipeline flow in an instant, or split-second emergency shut-off . . . you can get it with an EVERLASTING Valve. Less than a 70° turn of the lever turns the trick.

What's more, the EVERLASTING Valve *improves* with use. The rotating action of the sealing disc against the seat gives the valve a self-lapped seal . . . *everlastingly tight.* For the design of the EVERLASTING Valve forces the sealing disc into constant contact with the sealing surfaces around the port. Damaging grit can't get in between.

Mechanically, the EVERLASTING Valve is simple. *It has but eleven parts in all.* Maintenance can't be a headache. And remember the self-lapping feature—it has no equal for maintaining the drop-tight seal. *Furthermore,* EVERLASTING Valves are designed to "take it." *And they do!*

Made in straight lever and rack-and-pinion types, the EVERLASTING Valve is available in cast-iron, bronze or cast-steel. Sizes range from ½" to 6"; pressures up to 300-lb. EVERLASTING Valves conform to A.S.M.E. and other code requirements.

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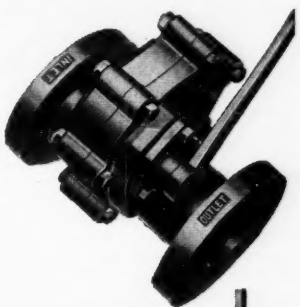

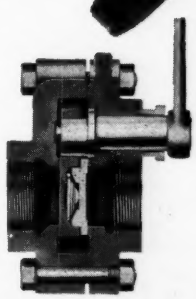

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EV-272

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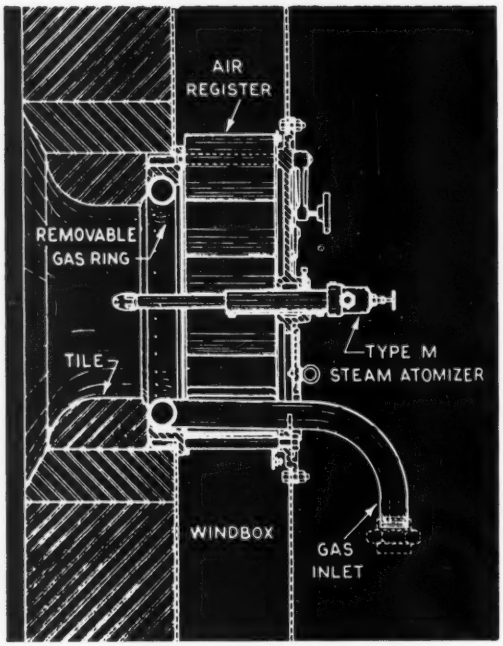

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BOILER FIREMAN'S HANDBOOK

by Joseph R. Darnell

No matter whether it's a problem concerning gas or oil burners, stokers, pulverized fuel burners, hand firing, air heaters or any apparatus found in the boiler room, this book will help you find the answer. This handbook which is the result of the author's 30 years experience in power plant practice, affords readers many helpful suggestions not only for the solution of combustion problems but tells how to sample and analyze flue gas, how to correctly measure temperatures, and describes the proper operation of numerous other pieces of apparatus found in the power plant.

Helpful in a hundred ways

CONTENTS: Fundamentals of Combustion. Why Flue Gas Temperature Goes Up When the CO_2 Goes Down. Sampling and Analyzing Flue Gas. Interpreting Flue Gas Analyses. Measuring Flue Gas and Furnace Temperatures. Coal Storage and Preparation for Use. Boiler Efficiency Calculated from Flue Gas Analysis and Temperature. Types of Air Preheaters and the Effect of Preheated Air on CO_2 Furnace Temperature and Flue Gas Temperature. Natural and Mechanical Draft. Draft Gages and the Measurement of Draft. Hand Firing Methods for Solid Fuels. Stoker Firing Methods. Fuel Oil Firing-Steam Atomization. Oil Firing Methods—Mechanical Atomization. Gas Firing. Pulverized Fuel Firing. Waste Fuels Firing. Heating Feedwater. Flexibility in Firing Equipment and Problems Involved in Converting from One Fuel to Another.

193 pages, 6x9, 139 illustrations.

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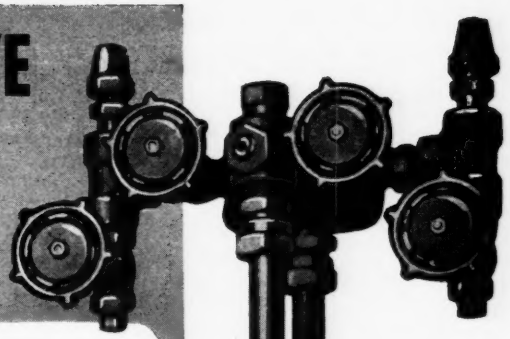
plained previously (Fig. 3) except that they do not have the superheating feature which is not required. 13,657 lb of steam per hr at the 450 psig level are required to produce 65,881 lb of condensate per hr at 90 psig for makeup and 6746 lb of 90 psig steam per hr which combines with the extraction steam for process. The steam transformer water treating plant need not be very extensive as the heat level is low. However, in this case the existing water treatment plant for the 450 psig boilers which are shut down is utilized. The 4 steam transformer units can be piped up so that when cleaning is required 1 unit can be taken out of service and the other 3 carried on the line for production of condensate. Of course, at such times the load on the high pressure boiler will have to be reduced proportionately, as the distilled water from one unit will not be produced. However, in the case of this plant it is not determined as one of the existing 450 psig boilers can be started up at partial load using treated feedwater to augment the difference required for electrical and steam requirements. The cleaning should not be too frequent as the existing water treatment plant for the 450 psig boilers is used to supply the steam transformers feed water and it is excellently treated water.

As can be noted only a small amount of heat, 133,515 Btu per hr is lost to the sewer as a result of blowdown from the steam transformers. Everything possible above the raw makeup feed water temperature is recovered by a blowdown heat exchanger. By means of heat exchange the feed water coming from the existing water treatment plant, deaerating heater at 212 F is raised to 320 F and the condensate obtained from the steam required goes out as part of the 65,881 lb per hr to the high pressure boiler deaerating heater. Also a high pressure feed water stage heater is employed taking steam from the 450 psig intermediate line. The condensate from this stage heater goes to the deaerating heater some of which flashes supplying steam for water heating. Because of the overall heat exchange arrangement a very small quantity of 580 lb per hr of 90 psig steam is required in the deaerating heater to give zero oxygen water. The deaerating storage tank is made large enough to give required storage to take care of swinging load conditions acting as a required reservoir. Such a cycle should have tremendous application where the steam to process, and electrical load are unbalanced on the electrical side or which for future plans indicate a trend that way. This seems to be the expected trend as industry is requiring more and more electrical power not in keeping with increased steam demand. With such

Reliance EYE-HYE

brings you accurate fool-proof remote water-level reading for any boiler or tank

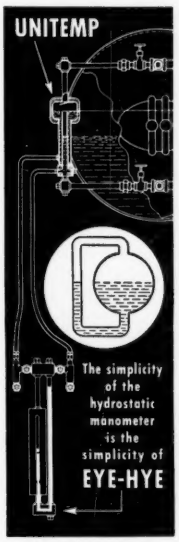


Standard equipment in thousands of power plants

● This dependable step-saving remote reading gage brings boiler water level indication down to eye level—indicates clearly in green fluid, brightly illuminated—unmistakable. When you've installed your first EYE-HYE, you recognize its potential value on all liquid-containing vessels, as a guard against liquid level accidents—as a help in achieving operating efficiency. Besides the main boilers you can use EYE-HYE on heater tanks, flash tanks and various types of storage vessels—even on sizes with level variation up to 12 feet.

Hydrostatic operation means constant full-range accuracy; factory calibration eliminates adjustments on location: EYE-HYE can't be tampered with in service. Easy to install—practically no maintenance. Can be placed in any convenient location where operators can see and read it *frequently*. . . . It pays you to learn more about the EYE-HYE. Write for full particulars.

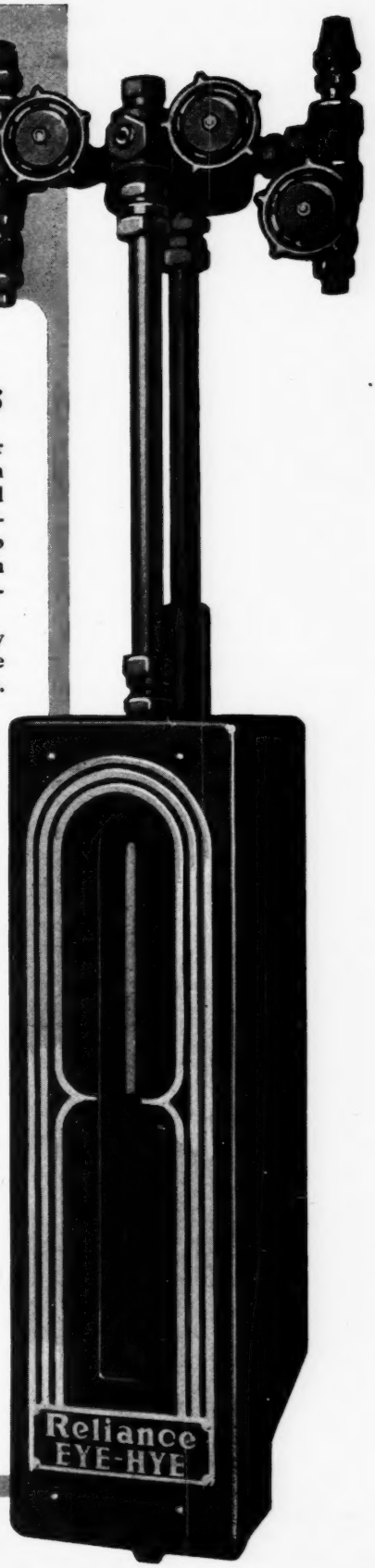
For the fellow who likes to know how things work, here's the story of EYE-HYE's a-b-c Simplicity



EYE-HYE operates on the principle of the U-tube manometer. EYE-HYE itself forms the bottom of the U; two tubes connecting it to the boiler drum complete the two legs.

Condensation of steam in the special reservoir—the Unitemp—maintains a level of water in one leg of the EYE-HYE hookup equal to the predetermined maximum *high* water level in your boiler. As water in the boiler rises or falls it exerts a varying pressure on the opposite leg. Unitemp also equalizes the *temperature,* and therefore the specific gravity, of water in both legs.

Counter-balancing these two pressures is a high specific gravity liquid in the bottom of the U-tube which will not mix with water, so water in the two legs pushes it back and forth according to the difference in hydrostatic head pressure. Thus the liquid (of a rich green color) is always in the same relative position between the two columns of water . . . and becomes the visual indication of the rise and fall of water level in the boiler.



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The unique features of the Belco Multiport Valve are that rubbing rotors are completely eliminated, pressure losses are reduced to a minimum and the high mechanical advantage makes it feasible to use a low H. P. electric motor for valve functions.

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The Belco automatic valve and Belcolite Resins can be applied to existing water softening installations to lower maintenance and chemical costs to such a degree that in most cases they will repay the original expense in a few months.

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Florida Industrial Equip. Distr., Miami, Fla.
Southwest: Watermasters Inc., Houston, Texas
Pacific: Deady Chemical Company, Los Angeles, Cal.

Belco

PROCESSES FOR REMOVAL OF WATER IMPURITIES

an arrangement high pressure boilers can be used with confidence, as feed water treatment is not a problem. Also, the desirable feature of variable pressure operation can very readily be used if a "once through" forced circulation boiler as indicated is used. However, reliable natural circulation boiler or boilers can be used just as well. This would be up to the individual desires, but "once through" forced circulation seem more justifiable both economically and practically.

In this cycle all of the steam that is used in process is contaminated and as indicated the condensate can not be recovered, it is lost. However, if practical the heat could be recovered.

COMBUSTION ENGINEERING AND SUPERHEATER MERGE

Merger of two power equipment manufacturers, Combustion Engineering Co., Inc. and The Superheater Co., was consummated on December 22 by approval of the stockholders of both companies. It became effective on December 31, 1948, under the new name of Combustion Engineering—Superheater, Inc.

The original Combustion organization was founded in 1914, its products including Type E, Type H and Coxe stokers. Subsequently it absorbed other manufacturers of fuel burning equipment and several boiler companies, the latter including the manufacturers of Heine, Walsh-Weidner, Casey-Hedges and Ladd boilers. Two of these companies started in the field in 1884, and several others were organized prior to 1900.

The Superheater Co. was organized in 1910 as the Locomotive Superheater Co., designing and building superheaters for locomotive boilers. Later, it expanded its line of products for locomotives and developed superheaters and other equipment for power plant boilers as well as marine and oil-country boilers.

PORTER NEW DETROIT EDISON CHIEF ENGINEER

George A. Porter has been appointed chief engineer of power plants of the Detroit Edison Co., in an announcement by James W. Parker, president. Mr. Porter came to the company in 1925 and has been assistant chief engineer of power plants since 1947. Mr. Parker also announced the appointment of Henry E. Macomber as assistant chief engineer of power plants and of William W. Brown as mechanical engineer of power plants.

Before being made assistant superintendent of the Delray power plant, Mr. Porter, who was graduated from Cornell as a mechanical engineer, was a maintenance man, foreman and maintenance engineer in the company. He has worked in the research, construction and production departments.

Henry E. Macomber has been in the production department since 1917, except for military duty in World War I and service in the Office of War Utilities, WPB, in World War II. He is a graduate in mechanical engineering from Michigan State College.

William Brown has been in the construction and production departments of the company since 1923. He was educated in the Kilmarnock Technical School in Scotland, and also served in the Office of War Utilities, WPB, in the last war. He is a consultant for the National Security Resources Board.

CHICAGO POWER SHOW PLANNED FOR NOVEMBER

The Midwest Power Show, first major exposition of power engineering to be shown in the Central West since 1937, will be resumed in 1949 at Chicago after a wartime lapse of more than 10 years.

Known officially as the 9th Midwest Engineering and Power Exposition, the show will be held November 11-16, inclusive, at Navy Pier, according to George E. Pfisterer, managing director whose headquarters are at 308 West Washington Street.

As in preceding shows, which were held here annually from 1926 to '31 and biennially to '37, the 1949 exposition will emphasize all equipment made for power generation, distribution, and use. Special attention is also devoted to the safety factor in power operations.

WESTINGHOUSE NAMES KEY ATOMIC POWER EXECUTIVES

The appointment of two key executives to guide the research and engineering for the Westinghouse Electric Corp. new Atomic Power Division has been announced.

Dr. John W. Coltman as manager of the Electronics and Nuclear Physics Department at the Westinghouse Research Laboratories. Dr. William E. Shoupp, distinguished nuclear physicist, was named director of research and Robert A. Bowman, experienced engineer especially familiar with heat transfer and ship propulsion problems, was appointed manager of engineering. Philip N. Ross, appointed assistant director of Research; E. L. Kuno, named assistant to the Division manager; and L. C. Mechling, Jr., appointed works engineer.

The Kuljian Corp., Engineers and Constructors, Philadelphia, Pa., has announced the appointment of Mr. Edwin Lundgren as their Washington, D. C. representative, effective January 1949. Offices are located at 1415 K Street, N. W.

Pennsylvania Power Co. directors have authorized the addition of a new unit to the company's New Castle Plant. The unit, to consist of an 85,000 kw turbo-generator and a 690,000 lb per hour boiler is scheduled for completion late in 1951. Contracts have been placed for the turbine unit and certain of the auxiliaries, and construction will begin early next year. The new unit will practically double the capacity of the New Castle station. Built in 1939, the plant contains two 44,000 kw units, the second of which was completed in December, 1947. The new turbine will operate at 1,450 psi and 1000 F with a reheat cycle. It is estimated that the addition will cost $11,500,000, and necessary transmission construction will cost an additional $1,000,000.

Ford, Bacon & Davis, Inc., announced the election as of January 1, 1949, of E. S. Coldwell as President, succeeding James F. Towers, who will actively continue as Chairman of the Board of Directors. Mr. Coldwell will at the same time succeed Mr. Towers as President of Ford, Bacon & Davis Construction Corp., Monroe, Louisiana, a wholly owned subsidiary of Ford, Bacon & Davis, Inc. Mr. Towers will also actively continue as Chairman of the Board of the Construction Corp.

The Swartwout Co. has established a company office at Philadelphia as of February first. In charge of the office at 1817 East Allegheny Avenue, are R. J. Jones and R. H. Frost, both technically trained men who have been connected with the engineering, sales and service activities of the factory at Cleveland for some time.

John P. Kleber has been named manager, Division of Municipal and Process Waters, Calgon, Inc., Pittsburgh, succeeding Owen Rice, who was recently elected vice president in charge of industrial chemical sales.

H. V. Nye has been named consulting engineer for the switchgear section of Allis-Chalmers electrical department, according to an announcement by F. C. Ludington, manager of the section.

Yarnall-Waring Co., Philadelphia, announces the following changes in its sales and manufacturing divisions: Joseph Kildare, Sales Manager has been elected Vice President in charge of sales and Frank W. Miller, Works Manager has been elected Vice President in charge of manufacturing. Carl Liberg, formerly associated with the company's New York sales office, is now located at the new district office in Buffalo and C. V. Peterson has been appointed sales representative in the Cleveland district.

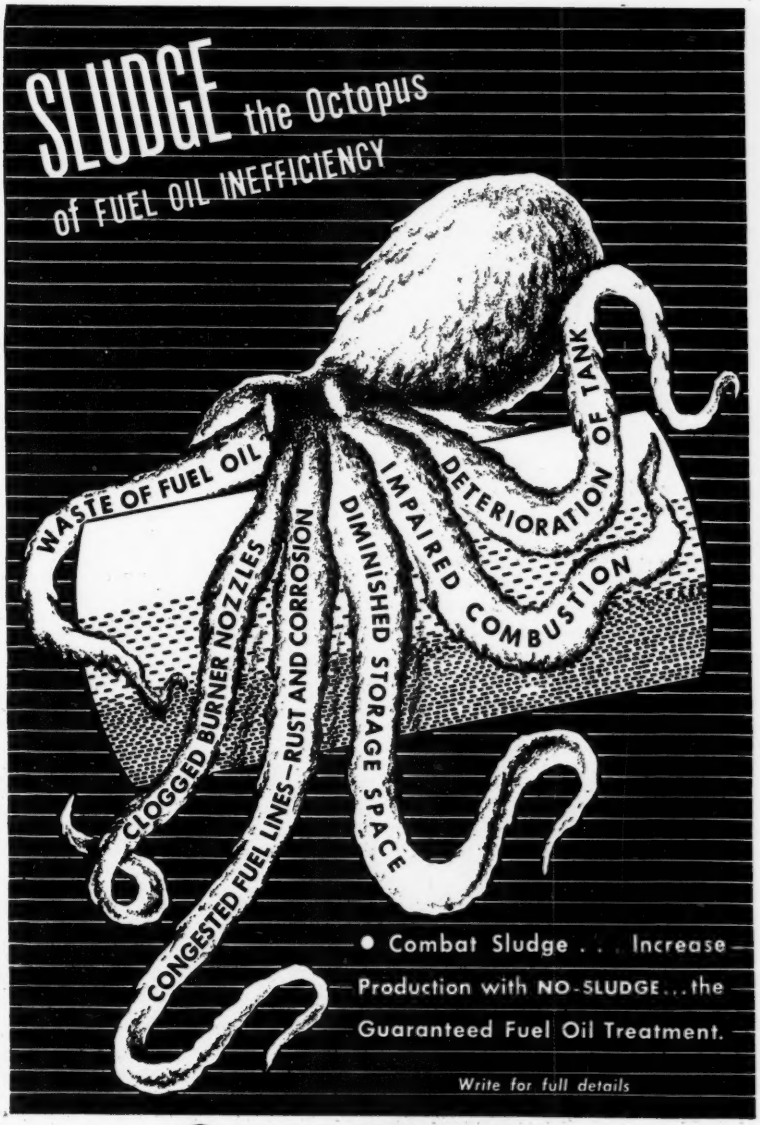
Wearn, Vreeland, Carlson & Sweatt, Inc., announced the removal of their offices to 43 Exchange Place, New York, New York.

Cochrane Engineering Corp. has increased its staff and moved to larger quarters at 309 W. Jackson Blvd., Chicago, Ill.

J. S. Overstreet, R. P. Allison, C. O. Hull and V. A. Sheals have been appointed to new positions in the Wire & Cable Division of the General Electric Company's Construction Materials Department, it has been announced by B. F. Ilsey, manager of the division.

Rockwell Manufacturing Co. has announced that henceforth its Pittsburgh Equitable Meter and Nordstrom Valve Divisions will be located at 25 Beale Street, San Francisco 5, California and 1102 Delano Street, Houston 1, Texas.

The appointment of Paul C. McMillan as manager of the newly created San Francisco office of Monsanto Chemical Company's export sales department was announced recently.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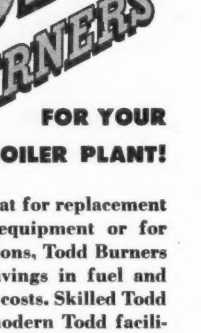

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Owen Rice, former manager of the Calgon Threshold Department, has been elected vice president in charge of commercial chemical sales, Calgon, Inc., Pittsburgh, a subsidiary of Hagan Corp. Mr. Rice joined a Hagan subsidiary, Hall Laboratories, Inc., in 1937, as a research engineer with the special assignment of developing threshold treatment.

Burns and Roe, Inc., has announced that Felix A. Mulgrew has been appointed to its Business Department in an executive capacity. Mr. Mulgrew, who served during World War II as Navigating Officer on the Aircraft Carriers *U.S.S. Bismarck Sea* and *U.S.S. Midway,* was formerly connected with the New York office of the Trundle Engineering Co. of Cleveland.

James D. Willcox, Jr., has just been appointed district manager of Elliott Co., Houston, Texas, territory according to an announcement by F. W. Dohring, vice president in charge of sales, Jeannette, Pa. Willcox came with Elliott in 1935 after graduation from Cornell University as an electrical engineer. From 1937 until his recent appointment, he was with the Atlantic district office, except for three years of service in the Navy during World War II.

A $3,000,000 motor manufacturing plant, which at peak production will be able to turn out more than 1,500 electric motors weekly, was officially opened by the General Electric Co. at San Jose, Calif., November 18. The San Jose factory, situated on a 57-acre tract which allows for multiple expansion of the present building, ultimately will produce all of the company's output of single-phase capacitor integral motors.

Henry E. Beyster, president of H. E. Beyster Corp., announced the appointment of Charles S. Lumley as Executive Vice President and Director of Engineering. Mr. Lumley also has been elected to the Board of Directors of the corporation and becomes a member of the Executive Committee.

M. A. King, formerly manager of engineering, has rejoined the Elliott Co. as engineering vice president, Jeannette Division. The announcement of his appointment was recently made by W. A. Elliott, president. Mr. King, who had previously been with Elliott for 27 years, was executive engineer for the turbine division of Worthington Pump & Machinery Corp. for the past five years.

Fisher Governor Co., Marshalltown, Iowa announces the appointment of A. E. Ehrke & Co. as the Fisher district sales representative in the Cleveland area. The Ehrke organization replaces Tomlinson

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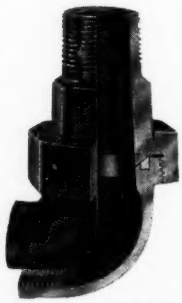

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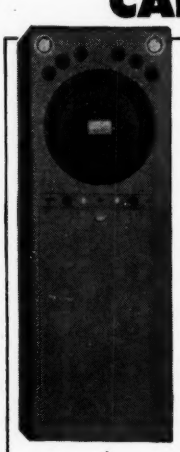

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ENGINEERS • DESIGNERS • FABRICATORS SINCE 1870

Steam Specialty Co., former Fisher representative. Bill Sixt and F. L. Zehe, formerly of the Tomlinson Co., are associated with the Ehrke firm. Address of the new Fisher office is A. E. Ehrke & Co., 5005 Euclid Avenue, Cleveland 3, Ohio.

E. W. Butzler, a member of the staff of Hall Laboratories since their establishment twenty years ago, has been appointed to the new position of business manager of the firm.

Mr. Butzler was for many years right-hand man for Dr. R. E. Hall, director of Hall Laboratories, as an engineering consultant on boiler water problems throughout the United States and Canada.

New ENGINEERING BOOKS

Rocket Propulsion Elements, by George P. Sutton. First Edition; size 5½ by 8½ in.; 294 pages; illustrated; cloth. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York; 1949. Price $4.50.

Constituting an introduction to the engineering of rockets, this book presents the basic elements and the technical problems of rocket propulsion and describes the physical mechanisms and the designs of rocket propulsion systems.

The progress made in this new field has been very rapid in the last decade. Nevertheless a number of principles and technical features are not yet fully crystallized or understood and it is, therefore, difficult to describe them clearly. This book, it is hoped, will help clarify the thinking along these lines and stimulate interest in further investigations.

The volume presents a historical outline of rocket development from the crude early rockets to late American models. Numerous illustrations showing performance graphs, schematic diagrams and photographs of rockets and many tables, including properties of metals at high temperatures enhance the value of this book.

• • •

Industrial Electronics and Control, by Royce Gerald Kloeffler. First Edition; 6 by 9 in.; 478 pages; illustrated; cloth. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York; 1949. Price $5.50.

This is a book designed to give the college engineering student a survey of the theory and applications of electronics in industry. The book, however, is of interest to practicing engineers as well, not only electrical engineers but also mechanical and chemical engineers. In fact, anyone interested in electronics and its commercial applications will find this book practical, thorough and understandable, even if his technical background includes only physics.

The book was written to give engineers a survey of the theory and application of electronics in industry. The early chapters are for the benefit of those whose previous training has not been in this field. Beginning with Bohr's early theory of the atom, Kloeffler proceeds to the basic theory of electron tubes, associated circuits and control component devices. The latter part of the book covers all the major applications in the industrial and commercial fields.

The book is well supplied with problems in introductory phases and in the application of industrial electronics. It is well illustrated. The author's style is simple and direct, so that the reader can learn the subject by his own efforts with little or no outside help.

• • •

Electricians' Pocket Companion, by Benjamin Goldberg. First Edition; 5 by 7¼ in.; 441 pages; illustrated; cloth. Published by Murray Hill Books, Inc., New York, 1948. Price $2.50.

In this handy-sized book for pocket or tool kit are hundreds of the facts, figures and methods needed constantly by the practical electrician. Covering the entire range of electrical subjects from motors, meters, and transformers to lighting, wiring, domestic heating systems and many others, this book brings together a wealth of information on code requirements, electrical circuit fundamentals, safety precautions, tools and time-saving work methods.

The application of electrical trade mathematics is explained in the simplest form, using ordinary arithmetic. Each formula is illustrated with a practical problem and a detailed solution of the problem.

Stripped of all non-essentials, Electricians' Pocket Companion is an exceptionally helpful reference for the electrical mechanic, apprentice, engineer, contractor, inspector and student.

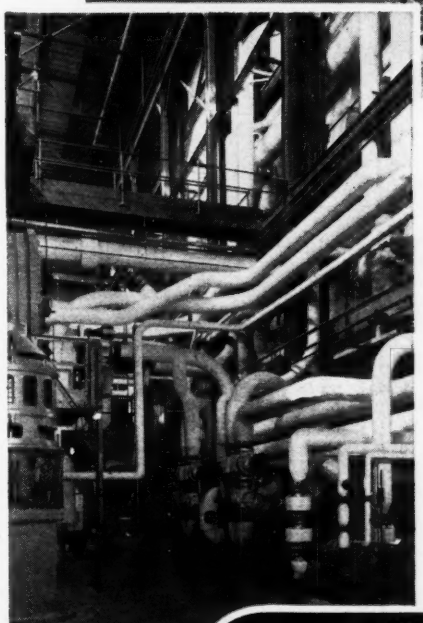
• • •

No Place to Hide, by David Bradley. First Edition; 5 by 7½ in.; 182 pages; Little, Brown and Company, Boston; 1948. Price $2.00.

This little book contains a straight down-to-earth description of what an atomic bomb can do to ships, islands, seaports, harbors and consequently to human beings. Its author was a radiological monitor with the task force that made the Bikini tests. He has given in this book a day-by-day account of the operation, seen not through the eyes of a technical expert, but through those of a doctor particularly interested in finding out the bomb's immediate and after effects on people, intensely aware that the results of these tests were of the utmost importance to him personally, as to each one of us.

The author flew over and under the gigantic mushrooming clouds that we have all seen in photographs, measuring the radioactivity of the air. He went into the holds of the target ships, checking whether it was safe for sailors to follow him. He tested the shoe soles of men returning from their ships, the drinking water, the fish in the lagoons for months afterwards, and he came home filled with wonder at the placid way in which civilian Americans chatter about "our" atomic bomb and "our" industrial might.

This is a book every American citizen should read and ponder, for the publicized facts that all the ships were not sunk at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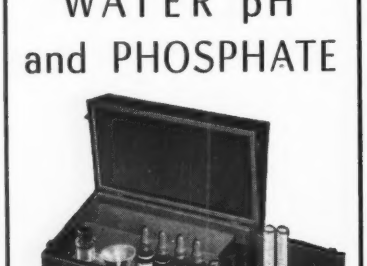
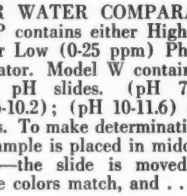


BOILER WATER COMPARATORS Model P contains either High (5-100 ppm) or Low (0-25 ppm) Phosphate Comparator. Model W contains same plus 3 pH slides. (pH 7.2-8.8); (pH 8.6-10.2); (pH 10-11.6) and accessories. To make determination, prepared sample is placed in middle tube in base—the slide is moved across until the colors match, and . . .



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You can make boiler water pH and phosphate determinations in only one to two minutes . . . quickly, simply, accurately . . . with Taylor Comparators. No technical knowledge is needed, and since the Taylor Liquid Color Standards are permanently enclosed in a molded plastic slide, there are no delicate single standards to worry about. All Taylor Liquid Color Standards carry an unlimited guarantee against fading.

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Bikini was far from the end of the story. When the Geiger men went in to check radioactivity after the underwater test, every tarred seam, every painted deck and stanchion and hull was broadcasting its warning. Deadly radiation had fatally poisoned every ship. The persistent power of the bomb after it has exploded is its greatest menace.

• • •

De Laval Handbook. First Edition; 5½ by 7½ in.; 271 pages; semi-flexible cloth. Published by the De Laval Steam Turbine Co., Trenton, New Jersey, 1947. Price $2.00.

This is an engineering data book for users of pumps, turbines, compressors and gears. It was compiled by the engineering staff of the De Laval Steam Turbine Co. and edited by Austin H. Church and Hans Gartmann. The book is designed to facilitate the work of power plant, industrial and design engineers in the design, construction and operation of steam, turbine power plants.

For the convenience of the user, the book is divided into six main sections, namely: 1, Mathematical, mechanical and fluid information of a general nature applying to more than one of the following sections; 2, Steam turbine data; 3, Centrifugal pump data; 4, IMO pump data; 5, Compressor, blower and exhauster data; 6, Helical reduction gear data; 7, Worm reduction gear data.

The book is attractively designed and produced; it should be on the library shelf of every design and operating engineer.

• • •

Introduction to Gas-Turbine and Jet-Propulsion Design, by Carl A. Norman and Richard H. Zimmerman. 280 pages; illustrated; size 6 by 9½ in.; cloth binding. Published by Harper & Brothers, 49 E. 33rd Street, New York 16, N. Y. Price $5.00.

The universal interest and intensive experimentation going on all over the world today in gas turbines, jet-propulsion apparatus and rockets, not only in military circles but also in industry and in private research institutions, has led to the writing of this book. It is based on lectures given by the senior author during the World War and was later worked over by both authors for use in regular undergraduate and graduate classes at the Ohio State University where Mr. Norman is Professor of Machine Design and Gas Turbine work and Mr. Zimmerman is Assistant Professor of Mechanical Engineering.

The book deals with gas turbines for stationary aircraft, marine and locomotive plants, and with rockets. It is designed to be an elementary and practical book on the subject. Every effort is made to present the material as concretely as possible so that engineers may understand it by actual visualization with a minimum of mathematical analysis.

The book begins with a discussion of the fundamental ideas on which gas turbines are based, then continues with fundamental mathematics, including the dynamics and thermodynamics, and explanations of compression and expansion necessary for understanding the subject. Chapter 3 discusses approximate gas turbine analysis beginning with the fundamental cycle and going on to those with regeneration and reheat and then to closed cycles. Chapter 4 shows how to make accurate computations; Chapter 5 explains entropy, expansion, compression and gas chart; Chapter 6 describes and illustrates combustion chambers; Chapter 7, turbine and turbine details; Chapter 8, compressors; Chapter 9, materials and general design considerations.

Following this are detailed discussions of aircraft power plants; stationary, marine and locomotive plants; and there is a final up-to-date chapter on rockets. An appendix gives derivation of disk formulas. There is an index and in the back of the book a folded chart of temperature, entropy and total energy relations for gases.

• • •

Elementary Steam Power Engineering, by Edgar MacNaughton. Third Edition; 640 pages; 497 illustrations plus many tables; size 6 by 9 in.; cloth binding. Published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $6.50.

To describe MacNaughton's well known text as a classic is no exaggeration; for, in its first two editions, it has been used by literally thousands of power engineering students and practicing engineers for a great many years. Since it discusses modern practice, it has superseded the famous Gebhardt, which also was a classic in its day. Also, it differs in treatment and style from Gaffert's book and also from that of Morse.

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college grade yet the mathematical treatment is simple enough to make it adaptable for vocational schools and for the general operating engineer.

Wherever feasible, practical phases of steam power engineering have been presented before the theoretical discussions; and, as in former editions, the author presents clearly and concisely the principles applying to construction and operation of steam power equipment. Experience in teaching during the war has demonstrated that when such principles are presented previous to further study in thermodynamics and advanced heat power, the latter will be made easier. At the same time the book gives the student a vocabulary of engineering terms and a knowledge of the construction of power plant equipment essential for the present day engineer.

Major changes in the Third Edition are: adoption of ASA symbols; use of Keenan and Keyes latest Steam Tables, which, with logarithms and other tables, have been placed at the end of the book; collecting of thermodynamic principles into a single chapter to follow the chapter on physical units; inclusion of a large Mollier diagram; revision of the chapters on fuels and fuel handling; and revision of the material on steam turbines to bring it up to date and include the mercury vapor and regenerative cycles. More data on heat transfer are included in this Edition. Descriptions of modern European boilers and a good list of general references for further study are given.

The illustrations are clear and detailed, showing many components that the student of elementary steam engineering often hears referred to but seldom sees, such as details of Kingsbury bearings, turbine blades and rotor construction, engine valves, construction of all types of fittings, traps, boiler auxiliaries, and so on. The book is well indexed.

• • •

National Electrical Safety Code. Size 5 by 7½ in.; 408 pages; cloth; published by the United States Government Printing Office, Washington, D. C., March, 1948. For sale by the Superintendent of Documents, U. S. Government Printing Office. Price $1.25.

This Handbook contains the first five parts of the Fifth Edition of the National Electrical Safety Code. Each of these parts has been approved by the American Standards Association as an American Standard. Part VI of the Code has not been included, because it is being revised under a new and separate Sectional Committee.

Parts I to V, inclusive, of the National Electrical Safety Code were revised separately by technical committees working under the Sectional Committee listed in this Handbook. These parts have been issued separately as National Bureau of Standards Handbooks H31 to H35 inclusive. This volume combines these Handbooks under one cover. The page numbers of the separate Handbooks have been retained to assist in the location of specific code rules regardless of the volume used. They appear in the caption at the inner or binding edge of each page.

In preparation of the first few editions of the code, the Bureau held meetings in many parts of the country and welcomed suggestions from everyone concerned. It reserved to itself, however, the final decision on all contested points. The procedure followed in later revisions subsequent to the establishment of the American Standards Association differs essentially from the former practice, in that final decision as to all details are made by the Sectional Committees, formally approved by the American Standards Association and operating under their rules of procedure.

The National Electrical Safety Code is now used by over half of the states for their power transmission requirements as well as by municipal governments, electrical power companies, telephone and telegraph systems and railroads.

• • •

Theory and Practice of Heat Engines. by Virgil Moring Faires. 388 pages; 251 illustrations; 8 tables; 6 by 9 in.; cloth binding; published by The Macmillan Co., 60 Fifth Avenue, New York City. Price $5.00.

This book is aimed at the needs of students taking a short course in heat power and is designed to implant knowledge of the application of the law of conservation of energy. The general energy equation is set up and applied over and over again. Material from the author's previous book on Applied Thermodynamics has been used, but this book represents an independent appraisal of the theoretical developments that is different from the usual book on heat engines.

Introductory chapters deal with equations of a perfect gas: forms of energy; heat, work and internal energy and ther-

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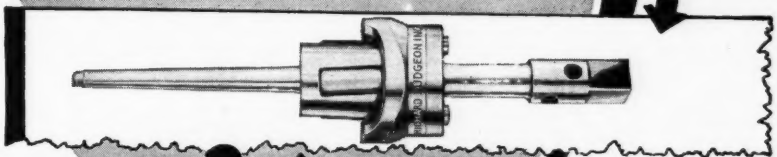

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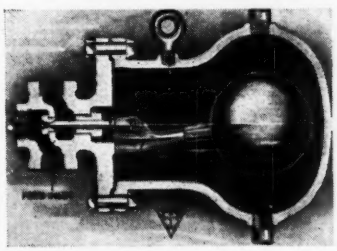

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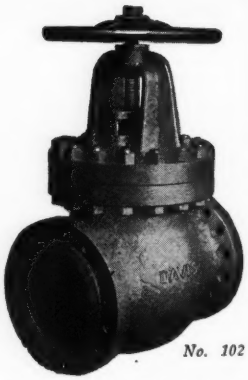

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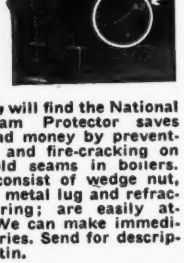

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modynamic process. The author then discusses compressors; internal combustion engines; steam turbines and reciprocating engines; steam generators; auxiliaries and combustion. The final chapter covers refrigeration. The book is indexed.

• • •

Bibliography on Industrial Radiology, 1945-1948, by Herbert R. Inseberger. Size 8½ by 11, fifteen mimeographed pages bound in loose leaf paper cover. Published by St. John X-Ray Laboratory, Califon, New Jersey, 1948. Price $2.00.

This is the second supplement to Industrial Radiology, the 2nd Edition of which was published in 1943 by John Wiley & Sons, New York. This supplement brings the bibliography up-to-date.

• • •

The Dynamics of Automatic Controls, by R. C. Oldenbourg and H. Sartorius. 276 pages; illustrated; 6 by 9 in.; cloth binding. Published by The American Society of Mechanical Engineers, 29 W. 39th Street, New York 18, N. Y. Price $2.00.

This book is a translation into idiomatic English of a German monograph brought back to this country by the U. S. Department of Commerce team of specialists from the industrial instrument industry in 1945. It was not generally available even in Germany but the few copies brought back to this country aroused so much interest that, through the efforts of various members of the ASME, it has been published. It has been translated and edited by H. L. Mason of Iowa State College with assistance by Minne E. Allen and Dr. Edward S. Allen.

The book is quite mathematical and, indeed, is not for those at the elementary level but rather for the most advanced

(Continued on page 138)

HELPFUL BULLETINS

(Continued from page 36)

use of Santobrite for the control of these organisms. The organisms are listed and the parts per million of Santobrite necessary to kill them are listed in the accompanying table. Chemical and toxicity characteristics of Santobrite are given. Monsanto Chemical Co.

VALVES, PIPING

34 Valves Bulletin—A new catalog section 12-H describes all types of the company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Details of design including operating mechanism, body design, disk piston, and other features are explained. Dimensional details are given in tabular form accompanied by dimensioned line drawings. A standard materials specification table is presented. Edward Valves, Inc.

35 Lubricated Plug Valves—Reference Book 39—Section 5, describes this company's self-sealed lubricated plug valves. A sectional washed drawing of a typical valve is shown with various features pointed out. The principle of the valve is explained by means of line drawings and list prices and characteristics are shown in tabular form. One section "Ways to Lubricate," is illustrated with excellent photographs which are accompanied by explanatory material. Homestead Valve Mfg. Co.

36 Safety and Relief Valves—Catalog No. 80 contains 24 pages and is bound in a separate heavy paper cover. The line of safety relief valves described are designed for the protection of boilers, compressors, heat exchangers, kettles, pressure piping and vessels, process equipment and regulators. Each of the various items are illustrated and the accompanying text tells the service for which the valves are designed, gives their service range, sizes available, connections and other pertinent information. Sectional views of each of the units is presented. Marine & Industrial Products Co.

MISCELLANEOUS

37 Fastenings Handbook—Fastenings of stainless steel are completely covered in Catalog No. 48. This is an 80 page,

thumb indexed reference book which describes the various items of stainless steel fastenings in the company's line. These items include screw machines, nuts, bolts and cap screws, rivets, set screws, pins, nails and many others. Tables of sizes and list prices accompany the description and a supplementary stock list which shows the thousands of sizes and variety of analyses of stainless fastenings the company has on hand in addition to those shown in the pricing catalog. This book will make an unusually handy reference for any engineer who has to deal with stainless steel fastenings of any type. Anti-Corrosive Metal Products Co., Inc.

38 **Protecting Metal**—Bulletin 1530 describes Apexior Number 1, a protective surfacing material for boilers and for power and processing equipment in similar wet-heat services. The bulletin also provides application data with information on special equipment for the internal coating of boiler, water-wall, and economizer tubes. The Dampney Co. of America.

39 **Vibration Prevention Handbook**—This excellent bulletin titled, "Why It Pays to Anchor your Machines with Unisorb," is a series of case studies showing how various studies have solved vibration in machinery by the use of felt absorption pads. Descriptions of the uses of these pads include the amount of savings in time and labor and a complete description of how the material controls vibration and noise. The illustrations used in the booklet are large and clear and locations of the vibration absorbing material are clearly indicated by colored circles. An exposition of how the material reduces maintenance cost and why it costs less to install it is included. Further applications of the material are listed on the last page of the 20 page booklet. The Felters Co.

40 **Ring Packing Technical Bulletin**—This new Technical Bulletin, TB918, comprising 12 pages, describes the company's line of ring packings and tells where they are used and how they are used in such places as hydraulic cylinders, hydraulic shock absorbers, wheel brake cylinders, swivel fittings and others. An excellent section shows how the ring packing operates and describes features of design. Tables of recommended dimensions for the rod type and the piston type are given. Greene, Tweed & Co.

41 **What's Your Cooling Tower I. Q.?**—Here is a chance to score your knowledge. This company, a manufacturer of cooling towers and spray nozzles, has prepared a series of question and anwser type monthly mail pieces with the title as given above. The first of the series deals with water distribution; the second, air movement; the third, facts and figures, etc. Although the subject is technical, presentation is informal and attractively illustrated and makes for enjoyable reading. At the same time the pieces are informative enough to merit serious study and a place in the permanent files of most engineers. The Marley Co., Inc.

42 **Retaining Rings**—Catalog 201 is a comprehensive specifications data book which describes the company's retaining rings. Illustrations show how the retaining rings are used on various types of bearings and all other types of moving parts. Photographs show how the rings may be installed and tables of dimensions and ring numbers are given. One section of the book shows how to assemble the external rings in ball bearing assemblies and how to assemble the internal rings. This section is illustrated with step-by-step illustrations. Spirolox Div.,. Ramsey Corp.

43 **Power Plant Cleaning**—A digest of 71 maintenance cleaning procedures that saves time and money in the power plant are described in this new booklet. This is a thorough-going yet concise guide to improve methods that expedite degreasing, descaling, cleaning and related tasks in power plants. It presents in convenient form helpful data on specific materials and procedures for performing more than 70 commonly recurring maintenance cleaning and allied operation in Steam Central Stations, Electrical Power and Diesel Power Plants. Power engineers will find helpful its many recommendations on equipment repair and maintenance, on steam-detergent cleaning, and on simplified paint-stripping procedures. Of special interest is the valuable information provided on scientific, safe methods for removing scale from heat exchanger, surface condensers, superheating apparatus, engine cooling systems, steam or water-jacketed equipment. Oakite Products, Inc.

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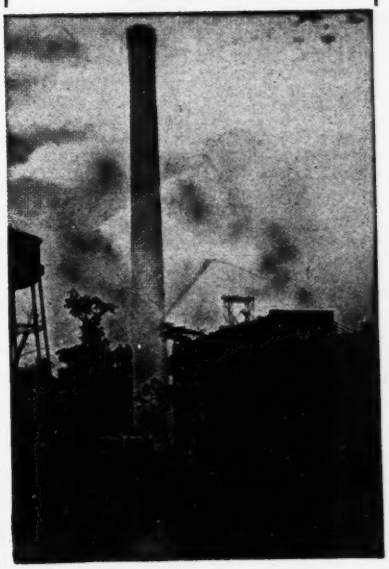

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POWER PLANT Construction News

Fairbanks, Alaska—Alaska Railroad Co., Anchorage, Alaska, has approved plans for new power plant at terminal yard at Fairbanks, with capacity of about 1000-kw. Cost reported close to $1,000,000. Work will begin at early date.

Forrest City, Ark.—Arkansas Power & Light Co., Pine Bluff, Ark., plans new steam-electric generating station near Forrest City, where company has taken over municipal power plant under long-term lease and will furnish local service in future. New power plant is part of agreement with municipality, and is reported to cost about $14,000,000, with transmission lines, power substations and other facilities.

Warren, Ark.—Bradley Lumber Co., plans rebuilding of mill and power house, recently destroyed by a tornado; power station caught fire and sustained heavy damage. Entire loss reported over $850,000.

Arcata, Calif.—G. L. Speier Co., Arcata, operating lumber mill, is interested in project with Arcata Plywood Co., recently organized, to construct and operate a plywood mill in this vicinity. A boiler plant will be built for service at mill, which will comprise several large buildings. Entire project reported to cost about $750,000.

Edge Moor, Del.—Delaware Power & Light Co., 600 Market St., Wilmington, Del., will construct proposed new power plant, previously noted in these columns, at Edge Moor, where site has been selected. Award is being made for structural steel framing and work on foundations will begin in near future. Cost estimated about $20,000,000. Completion is scheduled late in 1950.

Decatur, Ill.—Illinois Power Co., 134 East Main St., has arranged financing in amount of $25,000,000, to be used for expansion and improvements in plants and system over a period of months, including generating stations, power substations, transmissions and distribution lines.

Springfield, Ill.—Central Illinois Public Service Co., Springfield, will make extensions in plants and system during 1949 to cost about $16,000,000, including increased generating capacity, power substation facilities, transmission and distribution lines.

Evansville, Ind.—Southern Indiana Gas & Electric Co., 20 N. W. 4th St., has arranged an expansion program to cost over $5,000,000 by end of 1949, including addition to local Ohio River Station, now under way, with installation to comprise two 20,000-kw generators, two high-pressure boilers and auxiliary equipment. Extensions will be made in power substations, transmission and distribution lines.

Baton Rouge, La.—Dixie Electric Membership Corp., Baton Rouge, has tentative plans under way for new steam-electric generating plant, reported to cost close to $3,000,000, with turbine-generators, high-pressure boilers and auxiliary equipment.

Shreveport, La.—Southwestern Gas & Electric Co., 428 Travis St., plans extensions and improvements in boiler plant used local gas division, with installation of additional equipment. Cost reported close to $100,000. Work scheduled to be carried out at once.

Lansing, Mich.—Bd. of Water and Electric Light Commissioners plans improvements in boiler plant used for municipal water systems, including installation of new boilers and auxiliary equipment. Work will be carried out in conection with a 1949 expansion program in waterworks, entire project to cost over $1,000,000.

Traverse City, Mich.—City Council has arranged for a bond issue of $730,000, proceeds to be used for expansion and improvements in municipal power plant, with installation of equipment for increased capacity.

Duluth Minn.—Minnesota Power & Light Co., 30 West Superior St., has approved plans for addition to local steam-electric generating station, with installation of equipment for increased capacity. Extension will cost about $375,000, exclusive of equipment. Proposed to begin work soon.

Fox Lake, Minn.—Interstate Power Co., Dubuque, Iowa, has plans for new power plant near Fox Lake, with work scheduled to begin early in spring. No estimate of cost announced. It will be equipped for sizable output.

Twin Lakes, Minn.—Dairyland Power Co-operative, Inc., Rivoli Bldg., LaCrosse, Wis., has plans for new power plant at Twin Lakes, using Diesel engine-generator units and accessories, with initial capacity of about 5400-kw. Cost reported close to $1.000,000, with transmission line. Ellerbe & Co., First National Bank Bldg., St. Paul, Minn., are consulting engineers.

Kansas City, Mo.—Kansas City Power & Light Co., 1330 Baltimore Ave., has plans maturing for new steam-electric generating station in N. E. Industrial District, near Blue River, with installation to include turbine-generators with rating of 132,000-kw capacity, high-pressure boilers and auxiliary equipment. Proposed to begin work next spring. Cost reported over $25,000,000. Ebasco Services, Inc., 2 Rector St., New York, N. Y., is engineer.

Willoughby, Ohio—Cleveland Electric Illuminating Co., Illuminating Bldg., Cleveland, Ohio, plans new power plant on 45-acre tract of land at Willoughby, recently acquired. Details and estimates of cost will be determined at early date.

Oklahoma City, Okla.—Oklahoma Gas & Electric Co., 321 North Harvey St., has authorized fund of about $7,500,000 for expansion and improvements in electric and gas properties over a period of months, including generating stations, power substations, transmission and distribution lines, and other operating facilities.

Woodward, Okla.—Western Electric Cooperative, Inc., Anadarko, Okla., has plans for new power station at Woodward, with installation to include a 1000-hp. Diesel engine-generating unit and auxiliary equipment. Work will begin soon. J. F. Huitt, 6525 Clayton St., Clayton, Mo., is consulting engineer.

Dundee, Ore.—Hudson-Duncan & Co., 325 S. E. Water St., Portland, Ore., food products, plans rebuilding of boiler house at branch storage and distribution at Dundee, recently destroyed by fire. No estimate of loss announced.

St. Helens, Ore.—St. Helens Pulp & Paper Co., kraft papers, plans extensions and improvements in steam power plant at mill, including installation of new boiler and auxiliary equipment. Work will be carried out in connection with a general expansion program at mill, entire project to cost close to $1,500,000. Completion is scheduled in 1950.

West Mifflin, Pa.—Continental Can Co., Inc., 100 East 42nd St., New York, N. Y., plans boiler plant at new factory for manufacture of tin cans at West Mifflin, where tract of about 40 acres of land will be used. Entire project will cost about $2,500,000. Work will be placed under way soon.

Beaumont, Texas—Gulf States Utilities Co., 362 Liberty Ave., has arranged an expansion and improvement program to be carried out during next 36 mos., to cost approximately $95,000,000, including work now in progress. Project includes additions to local Neches steam-electric generating station to increase capacity by 100,000-kw, previously noted in these columns; extensions in Riverside power plant, Lake Charles, La., to advance output by 40,000-kw; and addition to Louisiana Station, Baton Rouge, La., to increase rating by 80,000-kw; and other generating plant extensions. Also power stations, transmission and distribution lines.

Tulia, Texas—Light & Water Dept., plans expansion in municipal power station, using Diesel engine-generating unit and accessories, reported to cost about $135,000.

Victoria, Texas—E. I. duPont deNemours & Co., Ammonia Dept., duPont Bldg., Willmington, Del., plans power house at proposed new chemical plant near Victoria, where tract of about 1700 acres of land has been secured. It will comprise a number of large buildings. Cost reported in excess of $5,000,000. Work will be placed under way soon.

Fairmont, W. Va.—Monongahela Power Co., Fairmont, has authorized an expansion and improvement program in 1949 to cost about $7,000,000, including generating plants, power substations, transmission and distribution lines. Work will be placed in progress at early date.

Milwaukee, Wis.—Continental Can Co., 100 East 42nd St., New York, N. Y., tin cans and other containers, is reported planning new branch plant on 50-acre tract of land on North Port Washington Rd., near Milwaukee. A boiler house will be built. Entire project estimated to cost over $4,000,000. It is understood that work will begin in 1949.

Racine, Wis.—Horlicks Corp., malted milk, etc., has plans under way for new power plant for factory. Details and estimates of cost will be determined soon. W. E. S. Dyer, Crosby Bldg., Buffalo, N. Y., is consulting engineer.

WHEN WE referred on page 57, January 1948 issue, to the fact that many of the present developments in treatment of coal as a raw material to produce gas and synthetic liquid fuels demanded more attention to development of machinery for the low cost continuous mining of coal, we had in mind the fact that half a dozen companies are working on machines for this purpose. Two specific devices of this kind have recently been made known to the public. One is the Colmol of Sunnyhill Coal Co., described and illustrated in a recent issue of *Fortune*. The other is the continuous miner of the Joy Manufacturing Co., recently described in the newspapers. You'll hear more about these and other devices for the same purpose in the immediate future.

★ ★ ★

"BITUMINOUS COAL Facts and Figures," a complete new data book about coal, profusely illustrated with graphs, pictograms and photographs and printed in three colors, has just come off the press and is being distributed. It is the handiwork of the Bituminous Coal Institute, public relations department of the National Coal Association, and is said to be the most complete ready-reference handbook on coal ever issued. Single copies of the book were mailed in October to executives of all member companies of the National Coal Association.

The 1948 Edition contains up-to-date information on bituminous coal reserves, production, distribution, consumption, mechanization, manpower and a host of other subjects. It is a 148-page volume of modern, easy-to-read graphs, illustrations, statistics, tables and text. The present-day progressiveness of the industry is emphasized.

Reports and tables on tonnages, statistics on mechanization, figures on costs, prices, income, labor and investment outlay as well as the text were developed by the Institute under the direction of Ralph C. Mulligan, Director of Public Relations, and Dr. Walter L. Slifer, Chief of the Statistical and Research Section. The book is copyrighted, but contains full permission to reprint any of the charts, graphs or text, provided credit is given to BCI and other indicated sources.

★ ★ ★

NEW RAW MATERIALS for the protective coating and other industries have been developed by W. A. Jordan and his associates at the General Mills Research Laboratories. Details on these improved materials, called Modiphats, are given in *Progress thru Research*. One of the materials, Modiphat 145, is formed by reacting the rosin fraction of tall oil with glycerine, forming a pale-colored, semi-solid, plastic material. Because it is tacky, stable, unaffected by humidity changes and because it has a solubilizing action on many other organic materials, it is potentially valuable, not only to the producers of synthetic coatings, but also to the manufacturers of adhesives, soaps and synthetic rubber compounds. It is also adaptable for use in soft rubber rollers and gaskets.

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TRAINED MINNOWS may be offered for sale some day, for use in testing industrial wastes, if some scientists at the University of Wisconsin ever commercialize some of their recent experiments, according to *Chlorination Topics*. These scientists have trained Bluntnose Minnows to react in one minute to water containing phenol. This reaction time is much quicker than any chemical test known and is sensitive at a level far below the concentration that could be tasted by human beings.

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(Continued from page 134)

readers who can attain the upper reaches of the higher mathematics—i.e., the calculus, Laplace transformation, and so on.

Automatic control has in recent decades spread to all divisions of technology and science. It produces the most concrete and specific results in operation; as all readers know, a great deal of our major equipment could not operate or even be designed to operate unless it could be assumed in advance that some means could and would be found to control it as desired.

Behind such very practical and intensely valuable applications lies a most fascinating theory. Entirely apart from the details of construction, operation and technological detail, all controllers possess in common certain dynamic properties. It is these underlying principles that are discussed in this book. There must be in the engineering field a group of men, whether large or small, who are interested in the theory of control and seek to carry it forward, explore all its details and make it a science ready for any sort of practical application. Such men will find this book invaluable.

The authors were members of the German company of Siemens and Halske. In this book they discuss first the concept of regulation, statement of the problems and symbols, then go on to basic theory, such as the control loop and its parts, the linear transfer system and mathematical treatment of the control loop. Following this they discuss continuous regulation and then nonlinearities, then discontinuous regulation. The last chapter is devoted to appropriate applications of various types of control.

For the serious and advanced student of automatic control, this book is a must.

• • •

Thermodynamics by Edward F. Obert, First edition, 571 pages, 6 by 9 in., cloth, illustrated; published by the McGraw-Hill Book Company, 330 West 42nd Street, New York, New York, 1948; Price $5.50.

This book was written to serve as a fundamental text in the field of thermodynamics and heat power. The book presents an unusually detailed and comprehensive treatment of the subject with emphasis on the logical development and application of the science of thermodynamics. The presentation is sufficiently rigorous and complete to satisfy the student and to serve as an introduction to more advanced topics.

More complete than most other text in the field, the book offers adequate material on air conditioning, refrigeration, gas turbine, etc., so that specialized courses in these fields are unnecessary in the undergraduate curriculum. An aim of the book is to provide certain essential material that must be understood by the practicing engineer and considerable stress is placed upon real machines, flow processes and properties of fluids. The illustrations are drawn in a manner to aid in the solution by emphasizing the concepts of the system and the surroundings.

As explained in the preface, the author had several reasons in mind for writing the book. The first objective was to present and emphasize certain essential material that must be thoroughly understood by the practicing engineer. The second objective was to emphasize the continuity of thought leading to the second law of thermodynamics. To accomplish this purpose the first law, its application and its limitation are stressed before the second law is introduced. While study of the characteristics of fluids is delayed until after the significance of the concepts of temperature and entropy are presented. The third objective of the text is to show that for many real fluids and for many real processes the simple perfect gas laws are inadequate and most desirable means of analysis at least for engineers who use slide rules for computations. To accomplish this purpose the properties of real fluids are presented and approximate solutions are studied before the concept of a perfect gas is introduced. Moreover, the comparison between real and perfect gases is stressed.

The kinetic theory is used as a logical means of introducing the student to the characteristics of real gases. The flow of fluids has been emphasized because the problem of fluid flow is one of the most usual tasks that the practicing engineer is called upon to treat. For the same reason irreversible processes are also stressed.

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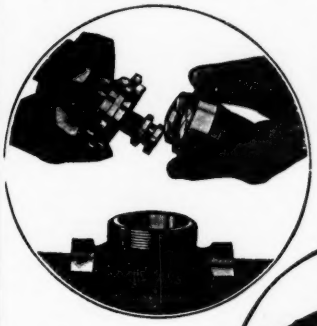

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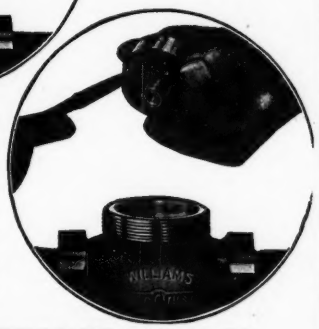

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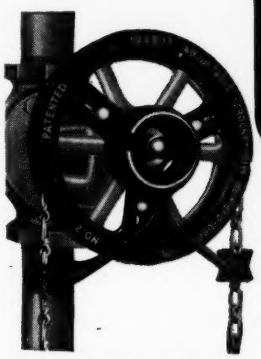

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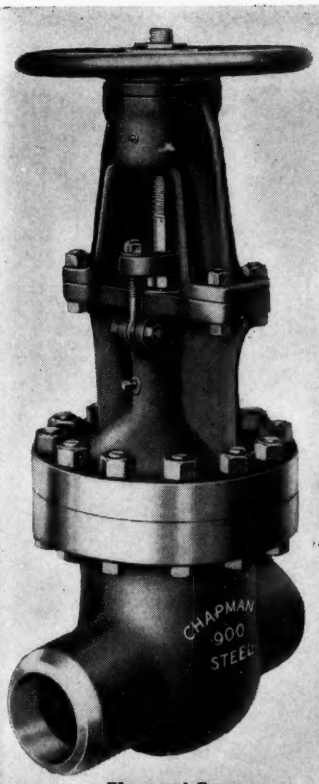

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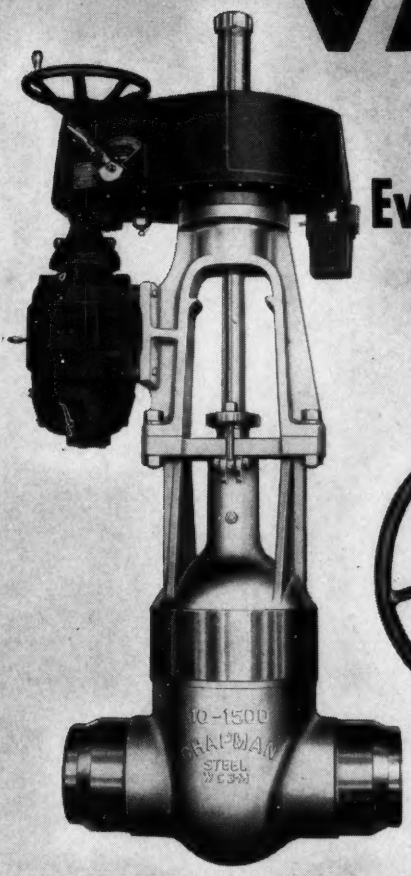

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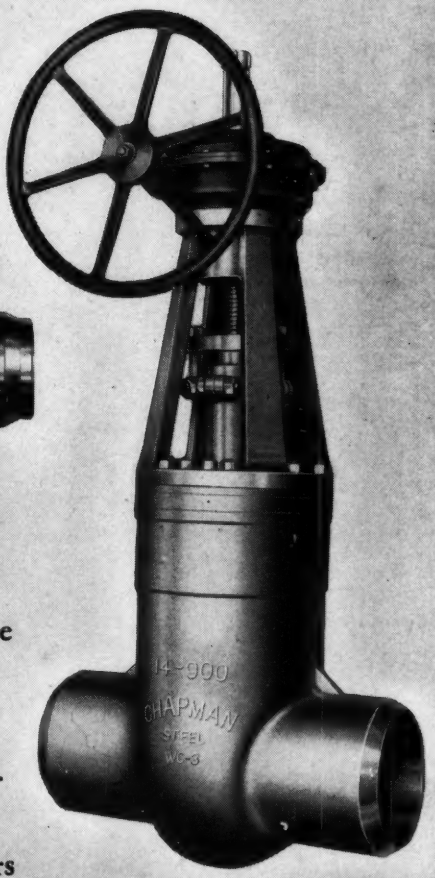

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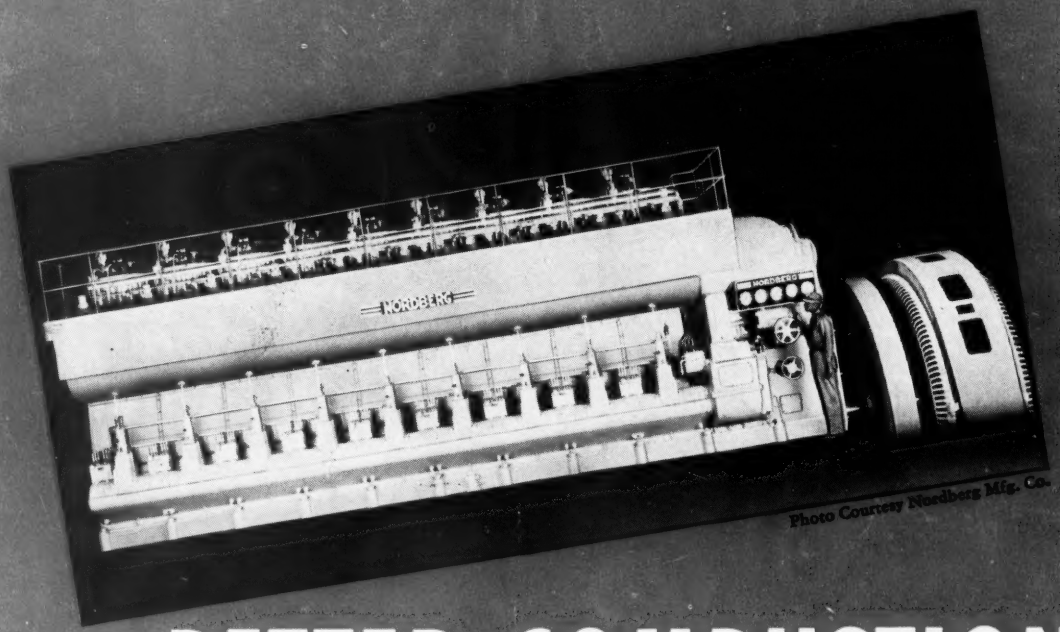

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